NATIONAL ACADEMY OF SCIENCES
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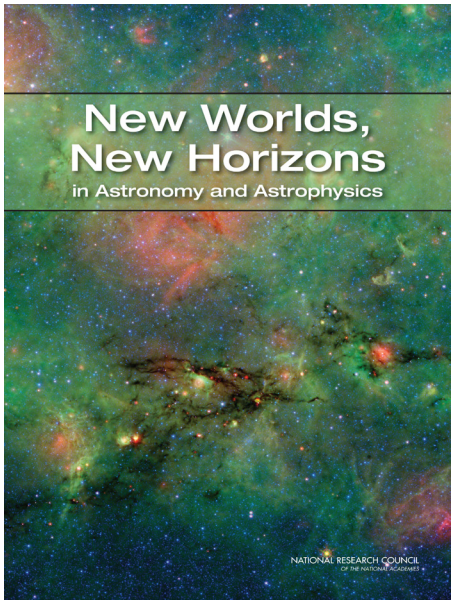
REPORT IN BRIEF

New Worlds, New Horizons
in Astronomy and Astrophysics

In recent decades, significant progress in the fields of astronomy and astrophysics has brought about a revolution in understanding of the origins and nature of our universe. This report, the result of a survey of astronomy and astrophysics for the decade of the 2010's, lays out a plan for sustaining the current progress in research over the coming decade and beyond. The proposed plan focuses on three science objectives: the exploration of the origins of the universe, the search for habitable planets outside our solar system, and the use of astronomical observations to investigate fundamental physics. The sixth in a series of decadal surveys, this study differs from its predecessors by reconsidering past unrealized priorities in addition to suggesting new research activities. The study also includes a detailed analysis of technical readiness and cost risks of projects and activities, resulting in a coherent program that fits within the survey's projected funding profiles for the three sponsoring agencies: the National Aeronautics and Space Administration (NASA), the National Science Foundation (NSF), and the Department of Energy (DOE).



Once limited to studying only visible light, astronomers and astrophysicists now observe the universe using the entire electromagnetic spectrum, from radio waves to gamma rays. Using these and other methods of investigation, the astronomy and astrophysics communities are able to answer profound questions about the origins of the universe and Earth's place within it. A compelling program of research that includes complementary space-based and ground-based facilities and foundational research efforts is needed to maximize scientific progress. *New Worlds, New Horizons* presents just such a program, while outlining the relationship of the federal program to the larger astronomy and astrophysics enterprise, discussing workforce development and other core issues, and describing in detail recommendations for the next decade of research.

Recommended Research Program for 2012-2021

The greatest strides in astronomical understanding have most often been the result of bold research initiatives. In recognition of this fact, the program proposed in this report is driven by a balance of medium scale and small-scale activities, along with ambitious large-scale efforts, listed in the tables below:

Large-Scale Space-Based Initiatives		
Priority	Recommendation	Description
1	Wide-Field Infrared Survey Telescope (WFIRST)	An observatory designed to settle essential questions in both exoplanet and dark energy research, which will advance topics ranging from galaxy evolution to the study of objects within our own galaxy.
2	Augmentation to Explorer Program	Support for an existing program that delivers a high level of scientific return on relatively modest investment and provides the capability to respond rapidly to new scientific and technical breakthroughs, thereby maintaining the breadth of NASA's program.
3	Laser Interferometer Space Antenna (LISA)	A low-frequency gravitational wave observatory that will open a new window on the cosmos by measuring ripples in spacetime. Will be used to survey binary systems in the Milky Way, probe the nature of black holes, and conduct precision tests of general relativity.
4	International X-Ray Observatory (IXO)	A high spectral resolution x-ray telescope that will lead to great advances on broad fronts ranging from our understanding of black holes to cosmology and the life cycles of matter and energy in the cosmos.

Large-Scale Ground-Based Initiatives		
Priority	Recommendation	Description
1	Large Synoptic Survey Telescope (LSST)	A wide-field optical survey telescope that will transform our observation of the variable universe and will address broad questions from indicating the nature of dark energy to determining whether there are objects that may collide with Earth.
2	Mid-Scale Innovations Program Augmentation	A competed program that will provide the capability to respond rapidly to scientific discovery and technical advances with new telescopes and instruments.
3	Giant Segmented Mirror Telescope (GSMT)	A large optical and near-infrared telescope that will revolutionize astronomy and provide a spectroscopic complement to the James Webb Space Telescope (JWST), the Atacama Large Millimeter/submillimeter Array (ALMA), and LSST.
4	Atmospheric Čerenkov Telescope Array (ACTA)	Participation in an international high-energy gamma ray observatory with sensitivity an order of magnitude greater than current telescopes.

To fully realize scientific opportunities and to create a robust program that optimizes scientific return, the plan balances the portfolio of projects with augmentations to the existing core research program. A series of unranked small-scale activity recommendations call for collaboration on international projects and support for individual investigators, instrumentation, laboratory astrophysics, suborbital space missions, technology development, and theoretical investigations, as well as public access to privately operated telescopes.

Medium-scale space-based recommendations include the *New Worlds Technology Development Program*, a competed program that will lay the technical and scientific foundation for a future mission to study nearby Earth-like planets, and the *Inflation Probe Technology Development Program*, a competed program designed to prepare for a potential next-decade cosmic microwave-background mission to study the epoch of inflation. On the ground, the proposed *Cerro Chajnantor Atacama Telescope (CCAT)* is a 25-meter wide-field submillimeter telescope that will expand discovery space and undertake large-scale surveys of dust-enshrouded objects.

Ultraviolet image of nearby Messier 81 galaxy produced by the Galaxy Evolution Explorer Telescope. This study recommends a high priority for the Explorer program. (Source: NASA Archives)

Other Recommendations

International Collaboration

The field of astronomy is made up of an increasingly globalized network of researchers, facilities, and plans. Advanced, high-cost facilities, typically involving the collaboration of multiple nations or collaboration of government and non-government institutions, are essential for major progress in astronomy and astrophysics. While requiring a high level of strategic planning, these partnerships offer opportunities to fulfill scientific goals that are beyond the reach of any single country.

Because international projects serve to maximize output from astronomical facilities and are essential to the continued vitality of the U.S. astronomy and astrophysics communities, government and non-government investors should consider approaches to enhancing U.S. participation in these projects, and to providing access to a larger suite of facilities that can be supported within the United States. Approximately every five years the international science community should come together in a forum to share scientific directions and strategic plans, and look for opportunities for further collaboration and cooperation.

Serving the Nation

The techniques and models developed in the process of conducting astronomical research do more than help fulfill human curiosity; they can also produce unexpected spin-off technologies, and help inform thinking on critical issues such as climate change. In a time of concern over waning interest in science and engineering, astronomical research plays an important role in capturing the public's attention and promoting scientific literacy.

Sustaining Core Capabilities

In response to the emergence of new methods of data collection and analysis, this report recommends renewed approaches to supporting theory and data handling. It also recommends that large astronomical data sets be curated to harness their long-term benefit. Discoveries in laboratory astrophysics continue to inform data interpretation and produce new insights. To enhance the scientific value of past, current, and future data sets, support for laboratory astrophysics programs should continue at current or higher levels over the coming decade.

A primary consideration for the authors of this report was the optimal use of limited resources. As such, the recommendations contained therein build upon existing research capabilities and emphasize certain capabilities for U.S. leadership, including all-sky synoptic imaging on the ground and in space, large aperture telescopes, exploration of non electromagnetic portals to the universe, technology and software, public-private and international partnerships, opportunities for new instrumentation, and interdisciplinary work, particularly between astrophysics and physics. They also include measures for the future evaluation of funding priorities and guidelines for creating a diverse and dedicated next generation of astronomers and astrophysicists.

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The National Academies appointed the above committee of experts to address the specific task requested by NASA, NSA, and DOE. Any opinions, findings, conclusions, or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the sponsor. The members of the committee volunteered their time for this activity; their report is peer-reviewed and signed off by the National Academies. This report brief was prepared by the National Research Council based on the committee's report. More information can be obtained by visiting the **Astro2010 website**. This report is a product of the National Academies' **Board on Physics and Astronomy** and **Space Studies Board**.

Free copies of the full report can be downloaded from the National Academies Press at http://www.nap.edu/catalog.php?record_id=12951.

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