

**PART II: Reports on Astronomy and Astrophysics and
the Hubble Space Telescope**

**THE DECADE OF DISCOVERY IN ASTRONOMY
AND ASTROPHYSICS**

Bibliographic Information: Astronomy and Astrophysics Survey Committee, Board on Physics and Astronomy, Commission on Physical Sciences, Mathematics, and Applications, National Research Council, *The Decade of Discovery in Astronomy and Astrophysics*, Washington, D.C.: National Academy Press, 1991 (available at <http://www.nap.edu/books/0309043816/html/index.html>). Committee chair: John N. Bachall.

PURPOSE

The National Research Council (NRC) charged the Astronomy and Astrophysics Survey Committee (also known as the Bachall Committee after committee chair, John N. Bachall of the Institute for Advanced Study) with

[s]urvey[ing] the field of space- and ground-based astronomy and astrophysics, recommending priorities for the most important new initiatives of the decade 1990–2000. The principal goal of the study will be an assessment of proposed activities in astronomy and astrophysics and the preparation of a concise report addressed to the agencies supporting the field, the Congressional committees with jurisdiction over these agencies, and the scientific community. . . . Attention will be given to effective implementation of proposed and existing programs, to the organizational infrastructure . . . as well as to suggesting promising areas for the development of new technologies.

BACKGROUND

The NRC commissioned the Astronomy and Astrophysics Survey Committee, a group of 15 astronomers and astrophysicists, to survey their fields and to recommend new ground-based and space-based programs for the 1990s.¹ The National Science Foundation (NSF), the National Aeronautics and Space Administration (NASA), the Department of Energy, the U.S. Navy, and the Smithsonian Institution all provided support on this project. The committee established 15 advisory panels to represent various wavelength sub-disciplines, as well as solar, planetary, theoretical, and laboratory astrophysics. The chairs of these committees helped the Astronomy and Astrophysics Survey Committee to select a broad-based representative group of more than 300 experts from academia, private firms, and public laboratories.

METHOD/APPROACH

The Astronomy and Astrophysics Survey Committee agreed that the primary criterion for setting priorities and making recommendations for new research would be its estimate of the scientific importance of each initiative. In forming its judgments of scientific importance, the committee took into account cost-effectiveness, technological readiness, educational impact, and the relationship of a project to existing or proposed initiatives in the United States and in other countries.

To supplement the findings from the more than 300 members of various committees who contributed to the report, many astronomers provided written input or participated in organized discussions. In all, more than 15 percent of American astronomers played an active role in some aspect of this study. The committee also consulted with distinguished foreign scientists on future directions in astronomy.

In addition to constructing a prioritized list of new scientific initiatives based on its assessment of the opportunities for fundamental scientific advancement, the committee also evaluated the existing

¹For a complete list of committee members and members of the Board on Physics and Astronomy and the Commission on Physical Sciences, Mathematics, and Applications, see Astronomy and Astrophysics Survey Committee (1991), pp. v–viii.

scientific infrastructure. In doing so, the committee took into account cost effectiveness and technological readiness.

FINDINGS AND RECOMMENDATIONS

The following subsections summarize the Astronomy and Astrophysics Survey Committee's findings and recommendations.²

Restoring the Infrastructure

Findings. Support for maintenance and refurbishment of facilities (and support for individual research grants in astronomy and astrophysics) have declined as a fraction of the total budget of the NSF, as a fraction of the NSF's total astronomy budget on a per-astronomer basis, and on the basis of real-dollar expenditures. As interpreted by the Astronomy and Astrophysics Survey Committee, the consequences of this decline include the loss of key technical personnel, limitations on young scientists' participation in research programs, delay of critical maintenance, an inability to replace old and obsolete equipment, and a lack of funds to pay for scientists at observatories and to reduce data collected by the scientific facilities into usable form.

Therefore, the committee's highest priority for ground-based research was strengthening the research infrastructure at universities and at the national observatories. This finding spawned the following three recommendations.

Recommendations

- The NSF should increase the operations and maintenance budgets for the national observatories to an adequate and stable

²The Astronomy and Astrophysics Survey Committee report categorizes the committee's recommendations into large, moderate, and small-sized programs, depending on the scale of the necessary resources. In lieu of this categorization, and given the scope of this RAND report, the following findings represent the committee's recommendations for large facilities only. For a more detailed presentation of all the committee's recommendations, see Astronomy and Astrophysics Survey Committee (1991), pp. 2–7 and 12–19.

fraction of their capital cost to repair the damage caused by a decade of deferred maintenance.

- The NSF should increase individual grant programs in astronomy to permit young researchers to take advantage of new opportunities for discovery, to appropriately utilize the large amounts of new data, and to enhance support for theoretical astrophysics.
- Annual funding increases should be allotted to (1) reverse the effects of deferred maintenance at the National Optical Astronomy Observatory (NOAO) in Tucson, Arizona, and the National Radio Astronomy Observatory (NRAO) headquartered in Charlottesville, Virginia; (2) upgrade receivers and correlators at the NRAO to improve the performance of its Very Large Array (VLA) of radio telescopes in Socorro, New Mexico, by a factor of ten; (3) provide the necessary computational resources to deal with the large-format arrays of optical and infrared detectors at NOAO; (4) replace antiquated equipment at the National Astronomy and Ionosphere Center in Puerto Rico (operated by Cornell University); and (4) hire new technical staff to service millimeter (mm) receivers, infrared arrays, and advance optics. *The Decade of Discovery in Astronomy and Astrophysics* report predicts that if the NOAO and NRAO were properly maintained for a decade, the maintenance improvements would restore the observatories' infrastructure to a healthy working condition.

Space-Based Programs

Finding. Advanced arrays of infrared detectors would give the Space Infrared Telescope Facility (SIRTF) the ability to map complex areas and measure spectra a million times faster than any other space-borne infrared telescope.

Recommendation. The Astronomy and Astrophysics Survey Committee recommended the completion of the SIRTF, the final component of NASA's Great Observatory program. The SIRTF orbiting observatory would be almost a thousand times more sensitive than earth-based telescopes operating in the infrared portion of the spectrum.

Ground-Based Programs

Finding. Three large ground-based initiatives are needed to provide state-of-the-art research facilities for hundreds of researchers working at dozens of different institutions.

Recommendations

- An infrared-optimized 8-meter telescope operating on Mauna Kea, Hawaii, would provide a unique and powerful instrument for studying the origin, structure, and evolution of planets, stars, and galaxies.
- The Millimeter Array (MMA), an array of telescopes operating at millimeter wavelengths, would provide high-spatial-resolution and high-spectral-resolution images of star-forming regions and distant star-burst galaxies. With a spatial resolution of a tenth of an arcsecond at a wavelength of 1 mm, the MMA would bring new classes of objects into clear view for the first time. The MMA utilizes the experience and technology that were developed for the VLA and for two smaller millimeter arrays.
- An 8-meter optical telescope, operating from the Southern Hemisphere, would allow U.S. astronomers to observe important objects in southern skies. All-sky coverage is essential for pursuing the answers to many of astronomy's most fundamental questions.