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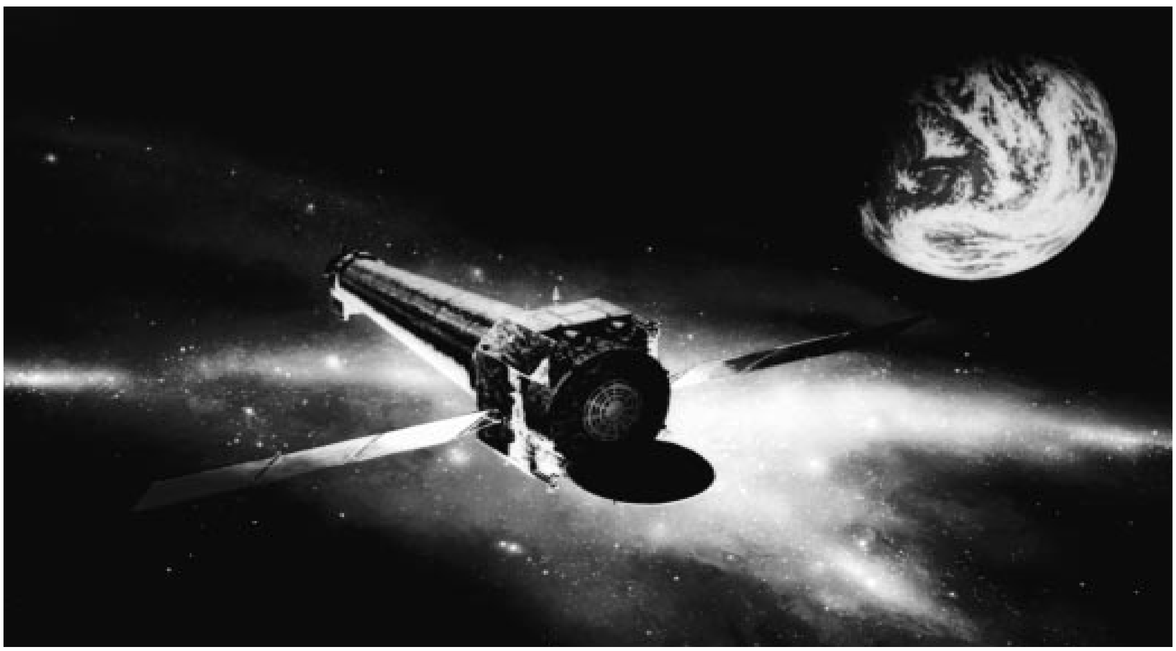
The Advanced X-Ray Astrophysics Facility



Later in this decade, NASA will launch a unique orbiting observatory which will open a window for more detailed views than ever before of the universe as revealed through X-rays. The Advanced X-ray Astrophysics Facility is expected to yield data that will improve knowledge and understanding in some of the most fundamental areas of scientific investigation.

Astronomers know whenever they observe X-ray emissions, they are viewing some of the most violent processes in the universe, since a tremendous amount of energy is required to generate X-rays. Such X-ray sources are among the most interesting and puzzling in the universe: neutron stars, black holes, debris from exploding stars, quasars, the centers of active galaxies, and hot gas in individual galaxies and galaxy clusters.

Since X-rays are absorbed in the Earth's atmosphere, it was not until the 1970s, with placement into Earth orbit of specialized X-ray instruments, that the first significant surveys of space for X-ray sources were made. The High Energy Astronomy Observatory (HEAO-2, widely known as the "Einstein Observatory") provided such exceptional results that astrophysicists, working with NASA, proposed development of a much more capable X-ray observatory. The result was the Advanced X-ray Astrophysics Facility or AXAF.

Originally planned as a single comprehensive mission, AXAF was restructured in mid-1992. The program restructuring was necessary to stay within reduced budget constraints, and to preserve

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a high percentage of the originally planned AXAF scientific capabilities.

The restructured program consisted of two missions; AXAF-I built around a high angular resolution mirror that supports imaging and dispersive grating spectroscopy at X-ray wavelengths; and AXAF-S, designed for broad band, non-dispersive X-ray spectroscopy studies, built around an X-ray calorimeter and lower resolution mirrors. As a result of congressional reductions in NASA's fiscal 1994 budget, the AXAF-S project was terminated in late 1993. Discussions are underway concerning the possibility of flying some of the AXAF-S instrumentation on the Japanese Astro-E mission.

AXAF-I

The AXAF-I mission will develop and place into orbit a telescope for capturing high-resolution images and spectra of X-ray sources. Its imaging observations will produce "picture-like" images analogous to those made in visible light with an optical telescope. It uses optics and detectors which are sensitive to X-rays to capture images of astronomical phenomena characterized by very high temperatures. AXAF-I's capabilities in the area of X-ray spectroscopy will complement its imaging function. Spectra, or spectrographs, reveal the temperature and "chemical fingerprint" of an object by separating the radiation received from it according to wavelength, much as a prism splits visible light into constituent colors. AXAF-I will utilize the high resolution of the AXAF mirrors to produce spectra at X-ray wavelengths of detailed features within X-ray radiating objects.

Key Features

To provide these capabilities, AXAF-I will have a unique mirror assembly. In an X-ray telescope, the mirrors are much different from those in optical telescopes. With their very short wavelengths, X-rays are not reflected from the surface of a conventional mirror. Therefore, X-ray telescopes use "grazing-incidence" mirrors — finely polished cylinders of glass that resemble ordinary drinking glasses with no bottom. The walls of the cylinders are very slightly angled so that X-rays graze off the surfaces, like a stone skipping on a pond. This configuration, coupled with a slight curvature of the surfaces, funnels the rays toward a point of focus behind the mirrors. AXAF-I's mirror assembly will consist of four sets of these cylindrical mirrors, mounted concentrically in a nested array in order to increase the area for collecting X-ray energy. The diameter of the largest mirror set will be 47.2 inches (1.2 m), making it the largest X-ray grazing incidence telescope to date. The focal length of the mirror assembly will be 32.8 feet (10 m).

Weighing roughly 10,000 pounds (5,200 kg), the observatory will be approximately 39 feet (11.9 m) long by 14 feet (4.2 m) in diameter. It is planned to be launched in late 1998, into a high elliptical orbit with a perigee of 6,000 nautical miles (10,000 kilometers) and an apogee of at least 60,000 nautical miles (100,000 kilometers). AXAF-I is designed to have an operational life of five years.

The scientific objectives of AXAF-I require that its design incorporate several sophisticated scientific instruments: a charge-coupled device imaging spectrometer and a high-resolution camera in the observatory's focal plane, provided by Penn State University (PSU)/Massachusetts Institute of Technology (MIT) and the Smithsonian Astrophysical Observatory (SAO); and two grating spectrometers behind the high-resolution mirror assembly, provided by MIT and the Space Research Organization of the Netherlands (SRON). During observations, collected data will be stored on-board and periodically transmitted to the ground for analysis.

Prior to launch, testing and calibration of the AXAF-I mirrors and science instruments will be performed at the Marshall Space Flight Center in Huntsville, Ala., in the unique X-Ray Calibration Facility.

Development

By competitive procurement, TRW Inc. of Redondo Beach, Calif., was selected in August 1988 as the prime contractor to develop what was then planned as the single-mission Advanced X-Ray Astrophysics Facility. TRW's major subcontractors are Hughes Danbury Optical Systems of Danbury, Conn.; Kodak Federal Systems Division of Rochester, N.Y.; and Ball Brothers Electro-Optics/Cryogenics Division of Boulder, Colo. Following the 1992 restructuring which created a two-mission AXAF program, the prime contractor's role was modified to encompass development and initial operation of AXAF-I.

Management of the overall AXAF program, including supervision of design, development, assembly and testing activities and the establishment of the Operations Control Center and the Science Center is performed by NASA's Marshall Space Flight Center. The Office of Space Science at NASA Headquarters in Washington, D.C., is responsible for the overall direction of the program.

AXAF Operations Control Center and Scientific Center

Once AXAF-I is in orbit, the focal points for the mission will be the AXAF Operations Control Center at the Marshall Space Flight Center and the AXAF Science Center in Cambridge, Mass. The two facilities will be electronically linked to allow efficient interaction in mission planning and data transfer. The facilities will each serve specialized functions:

The AXAF Science Center will assist the international science community in preparing to use AXAF-I's capabilities, specifically in areas such as preparing research proposals, planning science observations, and supporting calibration of the mirrors and instruments. The Science Center also will manage the receipt, calibration, processing, and distribution of scientific data and support users in the scientific analysis of these data. In March 1991, a contract was awarded to the Smithsonian Astrophysical Observatory for design, development, management and operation of the AXAF Science Center. The contract is managed by the Marshall Space Flight Center.

The AXAF Operations Control Center will receive observation requests from the AXAF Science Center and integrate them into a detailed schedule for transmission to the spacecraft. In addition, the Control Center will monitor spacecraft health and safety and provide capabilities for mission planning and scheduling, processing of telemetry, command processing and management, attitude determination and sensor calibration. It will interface with NASA's Deep Space Network for spacecraft communications.

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During its operational lifetime, AXAF-I will enable scientists to view in unprecedented detail the highly energetic aspects of the universe. The AXAF will bridge the region of wavelengths between those covered by the Hubble Space Telescope and by the Compton Gamma-Ray Observatory. It represents a major stride toward advancing the new age of astronomy and astrophysics.