

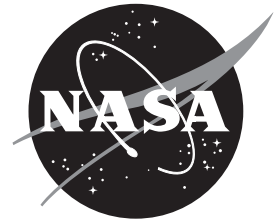
# NASA Facts

National Aeronautics and  
Space Administration

**Goddard Space Flight Center**

Greenbelt, Maryland 20771

AC 301 286-8955



FS-2000-11-011-GSFC

## NASA'S Space Science Enterprise and the Goddard Space Flight Center

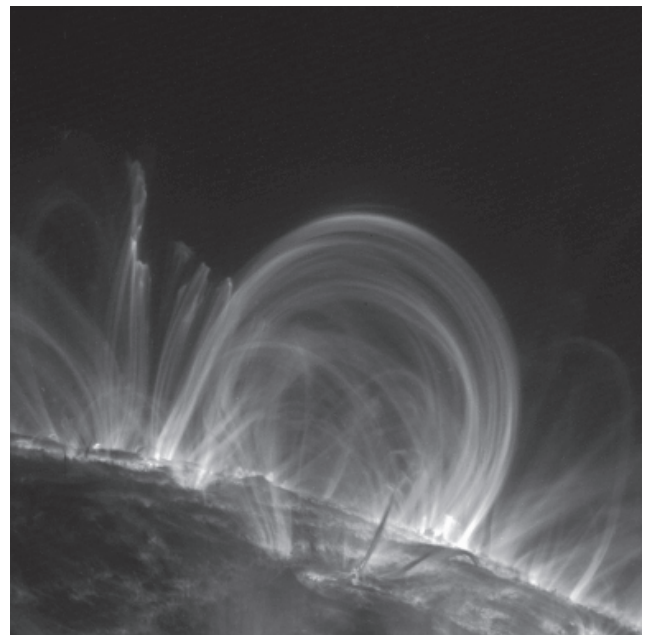
- How do violent outbursts from the Sun influence "space weather" around Earth? When, how, and why are these outbursts powerful enough to interfere with human activities on Earth?
- What happens near the edge of a black hole? How did galaxies form and grow in the early Universe?
- How and why do the physical properties of the moons and planets vary from one to another? What do these other worlds in the Solar System tell us about the history of the Earth and how it formed?
- What are the conditions under which life thrives and where do these conditions prevail around the Solar System and in the galaxy beyond?

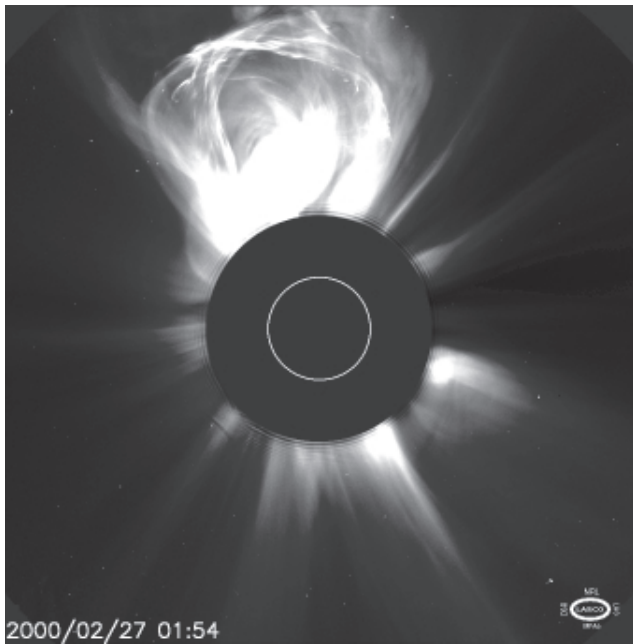
These are some of the fantastic questions that people at NASA's Goddard Space Flight Center work on every day, in support of NASA's Space Science Enterprise. This enterprise is organized around four fundamental scientific themes, which stretch from the inner biology of life to strange stellar objects in the farthest reaches of space. Goddard plays a significant role in each of these four themes, and carries lead responsibility for two of them.

### THE SUN-EARTH CONNECTION

It is amazing to step back and realize that our Sun is an ordinary star, similar to many others in the Milky Way galaxy. However, variations in the Sun's output from hour to hour and day to day have a direct impact on our planet, unlike the feeble light that reaches Earth from all of the other stars.

*TRACE images of hot gas loops on the Sun helped locate the mysterious energy source that heats the solar atmosphere to millions of degrees, hundreds of times hotter than the Sun's surface.*





*SOHO image of an eruption of hot, electrified gas from the Sun; such eruptions occasionally disrupt satellites, communications, and power systems on Earth.*

This is one major reason that Goddard scientists have studied the Sun and its effects on Earth's protective magnetosphere for decades, with a series of Orbiting Solar Observatories, the Solar Maximum Mission, and currently, the Solar and Heliospheric Observatory (SOHO), Imager for Magnetopause to Aurora Global Exploration (IMAGE), and other spacecraft. SOHO, a joint project with the European Space Agency, has operations and science nerve centers at Goddard, and reveals new details about the Sun's complex behavior on virtually a daily basis.

SOHO found streams of hot, electrified gas flowing like rivers beneath the surface of the Sun, and helped solve long-standing mysteries about the speed of the solar wind that streams outwards from the Sun. It has revealed the deep interior region where the Sun's magnetic field is generated, and has allowed scientists to "see" through the whole Sun and pinpoint disturbed regions on the side facing away from Earth.

The Advanced Composition Explorer (ACE) spacecraft allows scientists to accurately determine the temperature of individual solar "sneezes" known as impulsive solar flares, a first step toward understanding how these events accelerate particles from the Sun to extremely high velocities. Goddard's Transition Region and Coronal Explorer (TRACE) spacecraft has revealed frictional forces in the Sun's outer layer, or corona, that are hundreds of times stronger than expected. This friction, or viscosity, may help explain another long-standing mystery: why the corona is more than 100 times hotter than the Sun's surface.

The Dynamics Explorer mission of the 1980s and the ongoing Polar mission have both observed Earth's auroras — the rings of northern and southern lights — in order to better understand how energy from the Sun descends into Earth's atmosphere. Polar has detected oxygen expelled from the Earth's upper atmosphere in response to blasts from the Sun, and it has characterized the particles from the solar wind that drive auroras and the magnetic storms that affect power grids and communications systems. The upcoming TIMED mission will explore the long-overlooked middle atmosphere, where terrestrial weather systems connect to the electrical circuitry of the ionosphere and magnetosphere.

The International Solar-Terrestrial Physics mission has pulled together observations from SOHO, Wind, Polar and many other spacecraft with ground-based observations and computer models, letting scientists develop a complete picture of coronal mass ejections and other energetic events from their birth on the Sun to their arrival in the lower atmosphere of Earth. With measurements from Polar and the Japanese Geotail spacecraft, scientists have also directly observed the process of "reconnection" in which the magnetic field of an interplanetary

storm originating at the Sun hooks up with Earth's field in a "short-circuit" that funnels solar particles into the Earth's environment.

Future missions will build on these provocative findings. For example, NASA's Solar Terrestrial Relations Observatory (STEREO) mission will use two identically equipped spacecraft connected by radio links to provide revolutionary three-dimensional imaging of coronal mass ejections. This mission is one of a half-dozen cutting edge spacecraft being developed under the Solar Terrestrial Probes program led by Goddard.

Beyond launching spacecraft and conducting related research, NASA provides information to the National Oceanic and Atmospheric Administration (NOAA) to aid its official forecasts of "space weather."

## STRUCTURE AND EVOLUTION OF THE UNIVERSE

This astronomy-oriented space science theme centers on an emerging concept called Cosmic Journeys. It will be driven by a series of new missions that will take us to the limits of gravity, space and time, using technology with a power of resolution far greater than what current telescopes can muster.

Solving the mystery of gravity is important because gravitation controls the movements of nearly all that we can see in space — and even what we cannot see. The nature of gravity has puzzled the greatest scientific minds in history, including Isaac Newton and Albert Einstein. According to Einstein's Theory of General Relativity, gravity distorts space and time, especially in areas where it is extremely strong. NASA missions such as the Rossi X-ray Timing Explorer have inves-



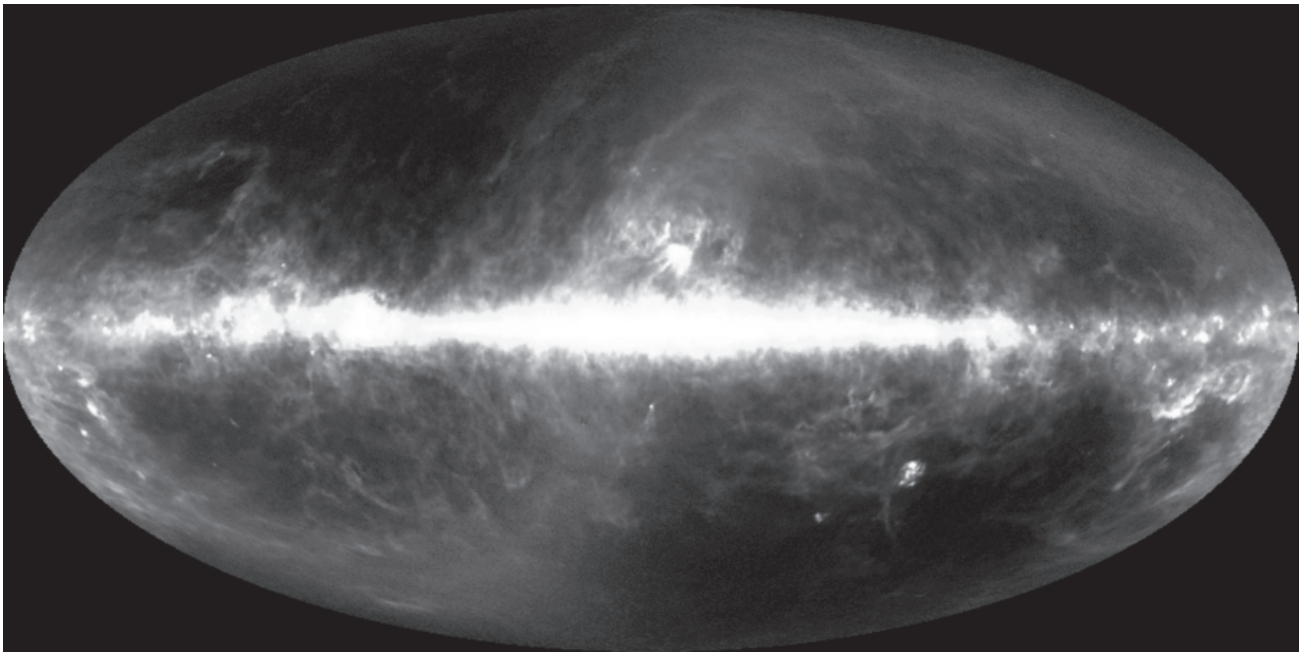
*This is a computer-generated illustration of hot gas swirling around a black hole; observations of these systems reveal the nature of gravity in extreme environments.*

tigated and tested Einstein's theory, but there is much more to learn.

NASA's Cosmic Journeys seeks answers to these questions by using the Universe as a laboratory to probe the most extreme environments of gravity and temperature. These environments exist in the vicinity of black holes, where gravity rules; in the very early Universe, tiny fractions of a second after the Big Bang, when temperatures were hot enough to briefly unite gravity with the other three fundamental forces; and on the grandest scale, where gravity may help to organize galaxies and clusters of galaxies into vast walls that surround cosmic voids.

Previous and on-going NASA missions such as the Cosmic Background Explorer (COBE), the Compton Gamma Ray Observatory and the Chandra X-ray Observatory have laid the path toward Cosmic Journeys.

Launched in 1989, Goddard's COBE spacecraft was the first space mission to address basic questions of modern cosmology, such as how the Universe began, how it evolved to its present state and what forces govern this evolution. According to the Big Bang theory, the Universe was created



*This image is a projection of the entire infrared sky created from years of observations by the robot spacecraft COBE.*

about fourteen billion years ago in a violent cosmic explosion that expanded space itself in all directions. COBE gained scientific fame for its very precise measurements of the first detectable structure in the Universe, which preceded the formation of galaxies and clusters of galaxies. COBE also showed that the spectral “fingerprint” of this radiation precisely matches predictions of the Big Bang theory.

Compton’s instruments detected more than 400 sources of gamma rays in the Universe, 10 times more than were previously known, and they recorded more than 2,500 gamma ray bursts when only 300 had ever been seen before. These awesome bursts, which astronomers now believe occur far outside the Milky Way, pop up randomly in the sky about once per day without warning and typically last a few seconds to a minute. In that brief flicker, they can release more energy than any explosion in the Universe since the Big Bang itself.

Chandra is finding that giant black holes are prevalent throughout the Universe in the hearts of normal and strange galaxies alike.

Over the next 20 years, the Cosmic Journeys missions will take us closer and closer to a black hole though the increasing powers of spatial resolution, the capability to detect fine detail. Each successive mission will further the inward journey by 10- or 100-fold increases in resolution, moving step-by-step toward the goal of zooming in a million times closer. Each stop along the way will amplify our understanding of the nature of matter and energy.

The GSFC-built Microwave Anisotropy Probe (MAP), currently scheduled for launch in 2001, will add more details to COBE’s pioneering discoveries about the early Universe. MAP will determine almost all the crucial parameters of cosmology that define what the Universe is like and what it will become.

In 2005, the Gamma Ray Large Area Space Telescope (GLAST) will begin searching for “dark matter,” a mysterious form of matter that contributes more than 90% of the Universe’s total mass. GLAST will study the universe at gamma ray energies, far beyond the ability of the human



eye, ordinary telescopes, or even X-ray telescopes.

The Constellation-X mission consists of four satellites that will work together to study the inner disk of matter swirling into a black hole. Like many space science spacecraft, this X-ray observing mission will produce measurements of reflected and absorbed radiation called spectra, rather than photographs. Scheduled for launch in 2008, it will be roughly 100 times more powerful than Chandra in its major areas of research. Constellation-X will also use this superior resolution to search for patches of hot gas floating freely in between stars and galaxies, which may define regions of dark matter.

NASA will not be alone in its Cosmic Journeys through gravity and time, cooperating hand-in-hand with the ground-based astronomical observatories run by the National Science Foundation, and the research and computer modeling capabilities of the Department of Energy as well as with international partners.

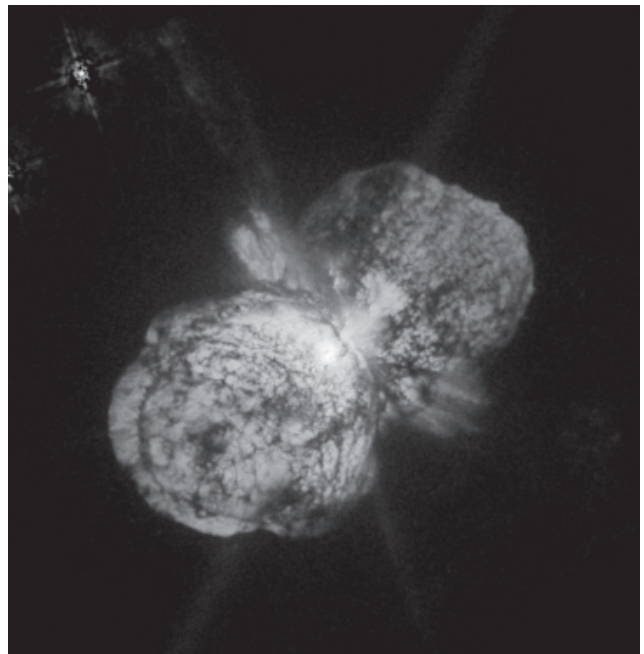
## ORIGINS

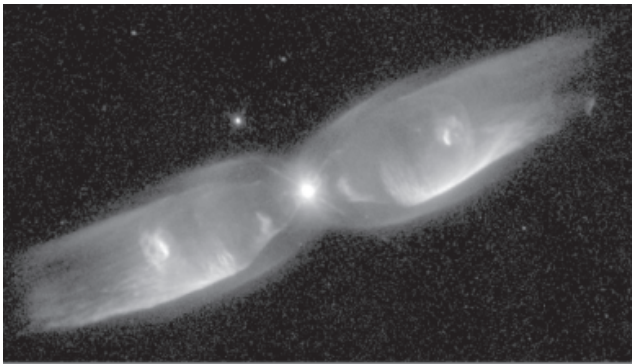
In just the past few years, astronomers have successfully achieved a goal discussed for centuries: detecting planets around other stars. Dozens of Jupiter-sized planets have been found by astronomers on the ground, by detection of the wobbles they induce in their parent stars. Now NASA is preparing to make the considerable technological leap necessary to find the smaller, rocky planets that might be capable of supporting life as we know it. The ultimate goal of NASA's Origins Program is to take a picture of another Earth-like planet and to measure the contents of its atmosphere, seeing if it contains key signatures of biological activity like methane or ozone.

Today, the Goddard-operated Hubble Space Telescope is the flagship of NASA's Origins Program. During its first decade in space, Hubble has given us highly reliable values for the age and expansion rate of the Universe, and the deepest ever exposure of galaxies in the early Universe, including some apparently still in the process of being assembled. Hubble observations also reveal stars with telltale disks of surrounding space dust that suggest regions where planets may form.

The Far Ultraviolet Spectroscopic Explorer (FUSE) has explored the hot halo of gas surrounding the Milky Way, generated by exploding stars, called supernovae. NASA's Space Infrared Telescope Facility (SIRTF) will be launched in 2001, bringing the invisible infrared emissions of celestial objects under the same scrutiny as visible light, gamma rays and X-rays.

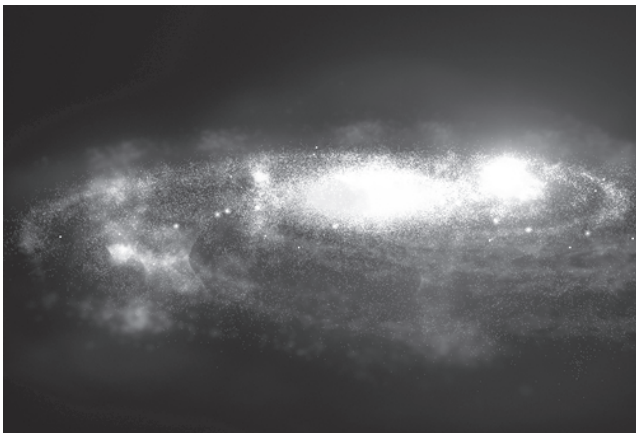
*Eta Carinae, a star 100 times as massive and five million times more powerful than our Sun, is subject to tremendous eruptions; 150 years ago, a giant outburst produced the huge, billowing pair of gas and dust clouds seen in this Hubble Space Telescope image.*





*This Hubble Space Telescope image shows a dying star in nebula M2-9 ejecting gas which is directed into a jet-like pattern by another star orbiting nearby.*

Then the real “odyssey” begins. Around 2009, Hubble’s Goddard-managed successor, the Next Generation Space Telescope (NGST), will enter space. NGST will sit in frigid space more than 900,000 miles from the night-side of Earth, equipped with a large deployable mirror with more than 10 times the light gathering power of Hubble. NGST will be able to observe the first generation of galaxies at immense distance from Earth in the early Universe.



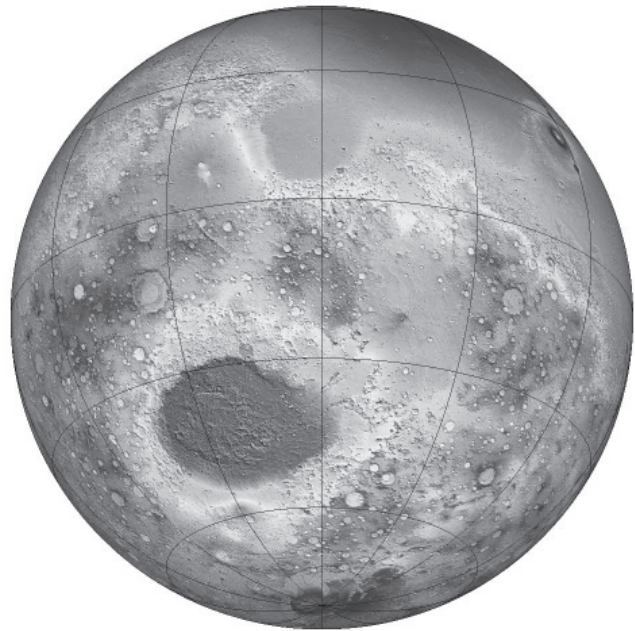
*This is a computer-generated illustration of the 500,000 degree gas halo surrounding our galaxy; NASA’s FUSE spacecraft measured the halo’s extent and determined that it probably was produced by thousands of star explosions over the galaxy’s lifetime.*

## SOLAR SYSTEM EXPLORATION

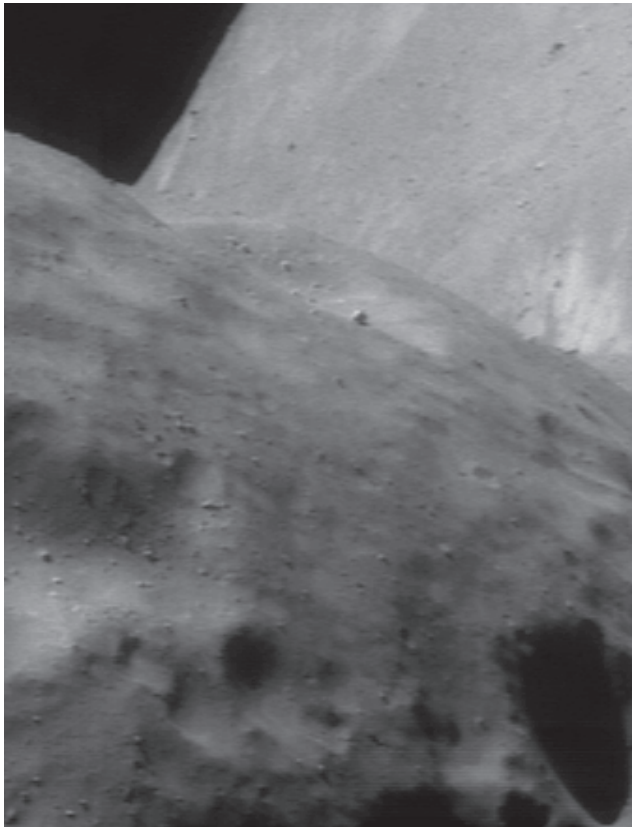
Goddard is also home to scientists who study the planets, moons, asteroids, and comets in our Solar System, some of which — notably Mars and Jupiter’s moon Europa — may hold traces of past or even present life.

NASA’s Mars Global Surveyor (MGS) mission has been circling and observing Mars since September 1997. Two of its instruments originated at Goddard.

The Mars Orbiter Laser Altimeter aboard MGS has fired more than 340 million laser pulses at the Red Planet, producing the first-ever accurate three-dimensional map of its surface and related estimates of its gravity field and internal structure. This 3-D map shows the ‘highs and lows’ of Mars in incredible detail, from the deepest impact crater in the Solar System to rocky highlands in the south that slope steadily downward to incredibly smooth, low-lying northern plains



*This is the most accurate map of the surface features and elevation of Mars to date, produced by the Mars Orbiter Laser Altimeter (MOLA) instrument on board NASA’s Mars Global Surveyor spacecraft.*



*This picture is a close-up of asteroid Eros, taken by the NEAR Shoemaker spacecraft, focusing on the bend in the asteroid that gives it a "peanut-like" shape.*

that may have supported an ancient ocean. MOLA was developed by GSFC's Earth Sciences Directorate and its technology is very valuable in studying Earth as well.

The Goddard-provided magnetometer sensor on MGS has given scientists their first evidence of a planet that once had a global magnetic field, but lost it when the planet's internal core of liquid metal cooled and solidified. This process left behind "fossil" magnetic fields in ancient crust that were detected by MGS.

A similar magnetometer from Goddard flew on-board NASA's low-cost Lunar Prospector mission that circled the Moon from January 1998 to July 1999. It confirmed the presence of localized magnetic fields that deflect solar wind particles and thereby

create the smallest "magnetospheres" in the Solar System. It also found evidence that these magnetized regions are located on the opposite sides of the Moon from the impact zones of ancient asteroids or comets that created its maria, or huge dark areas, suggesting that the mighty impacts had consequences that reached through or around the entire Moon.

Goddard scientists are flying another magnetometer and laser altimeter on NASA's Near Earth Asteroid Rendezvous (NEAR) mission. Now in orbit around the asteroid Eros, the NEAR spacecraft is gathering a unique trove of data concerning the Sun-orbiting "minor planet."

Other researchers from Goddard are actively involved in the study of the contents and circulation of the atmospheres of other planets. These properties are related to the conditions found in the earliest days of the Solar System four billion years ago, and the evolution of planetary climates since then.

Goddard scientists have studied Jupiter using data from NASA's orbiting Galileo mission and the probe that Galileo dropped into the gas giant's upper atmosphere in 1995. They also used Hubble and other instruments to study the tremendous impacts of the fragments of Comet Shoemaker-Levy 9 on Jupiter. Similar studies of Saturn will occur after the arrival of the NASA-European Space Agency-Italian Cassini mission in 2004.

## **TECHNOLOGY**

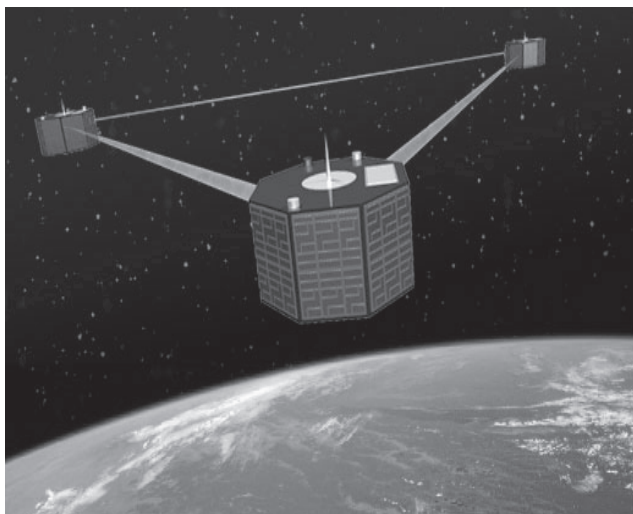
The nature of science is to gather knowledge by studying nature at increasing levels of detail with new approaches suggested by earlier findings. To continue NASA's unique series of discoveries about the Universe, future missions need to have improved



capabilities. The advanced technology development that enables these capabilities is also used to make spacecraft smaller and less costly to launch and operate than their predecessors.

Key areas of on-going technology development for space science at Goddard include:

- more sensitive detectors for scientific instruments
- large flexible structures that can be folded inside the nose of a rocket and deployed in space with great precision
- smaller and lighter high-performance computers
- navigation-related systems that allow tiny satellites to fly in precise formation with each other for joint observations of the Sun and distant stellar objects.



*Goddard is developing miniature but fully-capable spacecraft, called nanosatellites, that can be flown in constellations; such fleets promise an inexpensive way to make simultaneous measurements over vast regions in space, such as the Earth's magnetic field.*

## DATA DISTRIBUTION

Goddard's National Space Science Data Center (NSSDC) houses one of the largest and most active archives of information from satellites and deep space probes that can be found anywhere in the world. Imagery and other measurements returned to Earth from several dozen missions is available to the public and to scientific researchers via the Internet and on CD-ROMs. Refer to the NSSDC website at:

<http://ssdoo.gsfc.nasa.gov/>

## SUMMARY

For more information and many fascinating images, visit these pages on the Internet:

**NASA's Space Science Enterprise:**

<http://spacescience.nasa.gov/>

**Goddard Space Science news, mission summaries and related images:**

<http://pao.gsfc.nasa.gov/gsfsc/spacesci/spacesci.htm>

**National Space Science Data Center Photo Gallery:**

[http://nssdc.gsfc.nasa.gov/photo\\_gallery/](http://nssdc.gsfc.nasa.gov/photo_gallery/)

**Hubble Space Telescope home page:**

<http://hubble.stsci.edu/>