NASA Facts

National Aeronautics and
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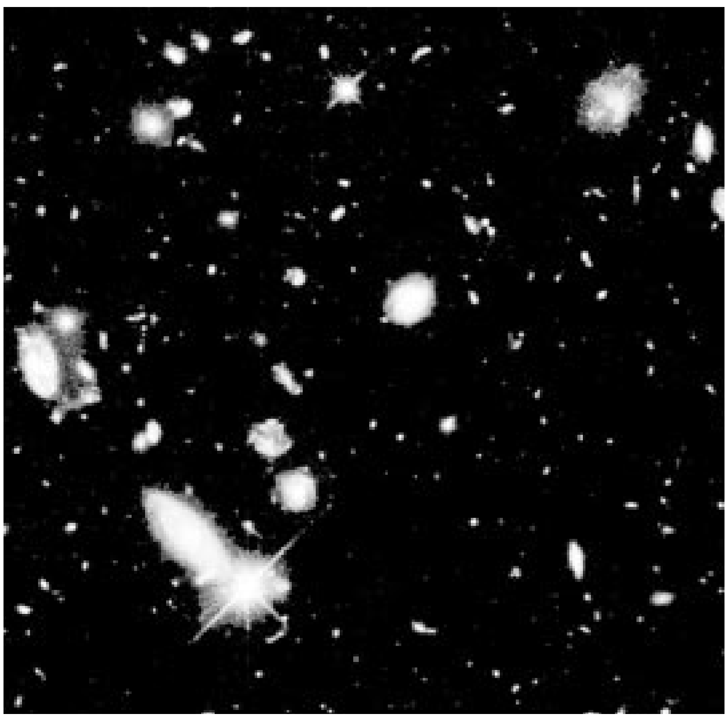
Origins Program

How did we get here? How did stars and galaxies form? Are there other planets like the Earth? Do other planets have conditions suitable for the development of life? Might there be planets around nearby stars where some form of life has taken hold? These questions have intrigued humanity for thousands of years. Astronomers approach these fundamental questions by looking far into the Universe, back toward the beginning of time, to see galaxies forming, or by looking very close to home, searching for planetary systems like our own around nearby stars.



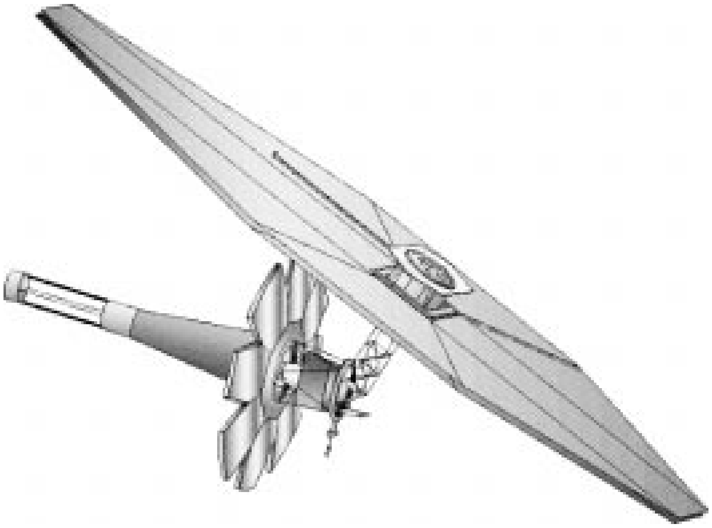
NASA's Origins Program will launch a series of missions to help us answer these age-old astronomical questions. Origins missions include four space-based observatories --- the Next Generation Space Telescope, the Terrestrial Planet Finder, the Space Infrared Telescope Facility, and the Space Interferometry Mission, and Earth-based observations using the Keck Telescopes on Mauna Kea, Hawaii. Detailed studies have begun on two of these new astronomical observatories that will be launched in the middle of the next decade. The Next Generation Space Telescope (NGST) will be a large single telescope, folded to fit inside its launch vehicle and cooled to low temperatures in deep space to enhance its sensitivity to faint, distant objects. It will be a follow-on observatory to the Hubble Space Telescope, peering even further back in time .

The Terrestrial Planet Finder (TPF) will consist of a collection of small telescopes functioning together to make images as sharp as those from a single telescope the size of a football field. The Planet Finder will enable a search for planets like Earth and look for evidence of life on those planets by carefully examining the colors of the emitted planetary light.

Both of these instruments will take advantage of dramatic new technologies to make instruments larger, lighter, and less expensive than the Hubble Space Telescope, but with the capability to go even beyond Hubble’s stunning discoveries.

Infant Galaxies in the Early Universe

The scientific riches from the Hubble Space Telescope show much more about the early Universe than we ever dreamed of. The distant universe is filled with billions of faint, infant galaxies. Galaxies, including our own Milky Way, are clouds of hundreds of billions of stars. We still do not know how galaxies



Next Generation Space Telescope

are made, but Hubble tells us how to look for them. Origins will teach us more about the first generation of galaxies and stars, formed soon after the Big Bang.

This will teach us more about the formation of the first chemical elements of life, including carbon, nitrogen and oxygen, and the scattering of those elements throughout the Universe. Those key elements were eventually incorporated into planets and biological systems.

Star and Planet Formation

The Hubble Space Telescope photos show magnificent pillars of gas in our own Milky Way Galaxy, where stars like our own are forming out of giant gas clouds between the stars. Other Hubble photos of the stellar nursery in the constellation of Orion show compact disks of material that may be solar systems, like our own, in the process of forming.

Infrared Light—Heat from the Cosmos

To learn more about how planetary systems, stars, and galaxies form, we must look at new wavelengths of light. We must look in the infrared portion of the light spectrum The expansion of the Universe after the Big Bang has stretched the wavelengths so that galaxies that are intrinsically blue look red to us. This so-called Doppler shift, or red shift, means that the farther away and younger a galaxy is, the redder it appears. To see baby galaxies immediately after they form, we need to use infrared wavelengths three to 20 times longer than visible light. There is a second, critical advantage of infrared light: while the newest stars and planetary systems are hidden from view by dust grains inside the gas clouds, infrared light lets us see through the dust to witness the cradles of star birth.

The Next Generation Space Telescope (NGST) -- A Sharper Image

We need a big telescope to make crisp infrared images and to collect enough light to study distant, still-forming galaxies. In the middle of the next decade, NASA will launch the Next Generation Space Telescope (NGST), a successor to the Hubble Space Telescope. NGST will be up to 25 feet across, much larger than even the Space Shuttle could carry in one piece. NGST will use new technologies so that it can be deployed automatically after launch. Its mirror will be very thin and will be adjusted to the proper shape after it is cooled down to operating temperature. The NGST will be placed in an orbit far from Earth, away from the heat radiated by our home planet. Its operating temperature will be low enough that even its own thermal energy does not swamp faint astronomical signals.

Finding Planets

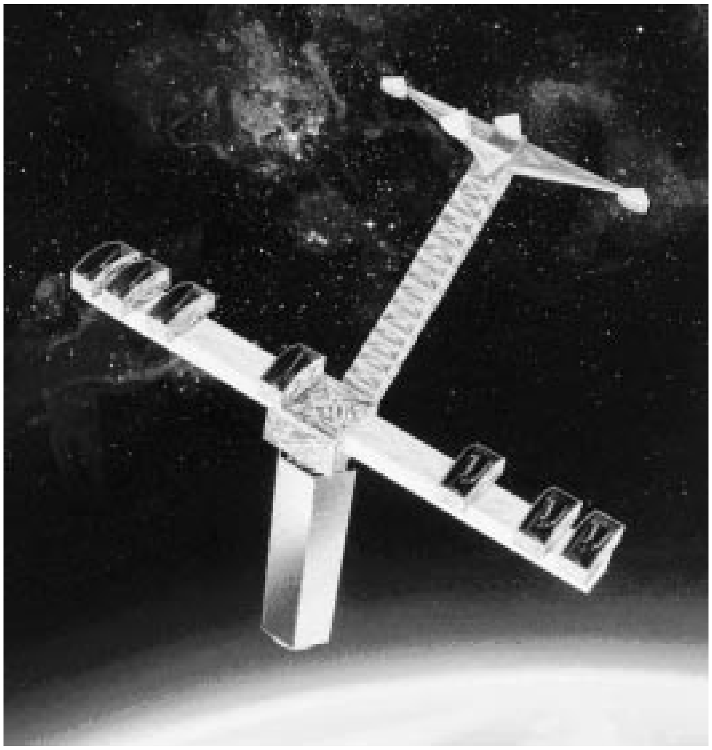
Can we find planets beyond our solar system? Are there other planets capable of bearing life? How do planets form? These are some of the questions to be addressed by the Terrestrial Planet Finder, which NASA is planning for the first decade of the new century. The challenge of finding an Earth-sized planet orbiting even the closest stars can be compared to finding a tiny firefly next to a blazing searchlight thousands of miles away. The infrared, or heat radiation, from a star is a million times brighter than the planets that huddle around it for warmth.

Finding Life

Astronomers can analyze the colors of the infrared radiation from planets up to 100 light years away, searching for atmospheric gases such as carbon dioxide, water vapor, and ozone. Together with the temperature and radius of the detected planets, this information will allow astronomers to determine which planets are habitable, or even whether they may be inhabited by rudimentary forms of life.

Terrestrial Planet Finder (TPF)

To find other planets and characterize their atmospheres, NASA scientists are planning to fly a type of observatory called an interferometer. An interferometer consists of a collection of several telescopes which function together to produce an image much sharper than would be possible with a single telescope. To



Space Interferometry Mission

ensure maximum sensitivity, this Terrestrial Planet Finder (TPF) will be sent into deep space, perhaps as far away as the orbit of Jupiter, removed from the haze of glowing dust in the inner solar system. NASA's Terrestrial Planet Finder is currently conceived as a suite of 4 telescopes, each about 80 inches across, precisely located on a 240 foot long truss and beaming their light to a common focus. The infrared light collected by each telescope will be carefully combined with that from the other telescopes in such a way that the starlight is rejected, but the light from the planets is collected and analyzed.

Near-term NASA Projects -- Scientific and Technological Stepping Stones

While the Next Generation Space Telescope and the Terrestrial Planet Finder will be the crowning jewels in the Origins program, three other NASA astronomy projects are closely related to the goals of searching for our astronomical beginnings in the early Universe. These missions are the Space Interferometry Mission, the Space Infrared Telescope Facility and the Keck Interferometer in Hawaii. These near term missions provide valuable scientific information and important technological testbeds that will reduce the cost of later missions.

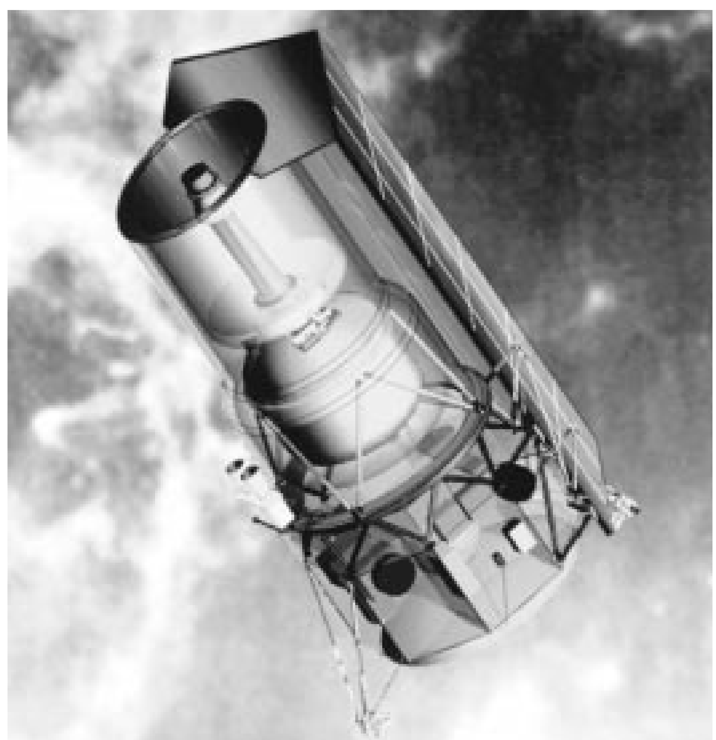
Space Interferometry Mission (SIM)

NASA plans to launch its first space interferometer as a precursor to the more ambitious Planet Finder. The Space Interferometry Mission (SIM) will allow scientists to "take measure of the universe" by providing the absolute positions of stars with a precision of a few millionths of an arcsecond. With this great precision, SIM would enable someone on Earth to see a man standing on the moon, switching a flashlight from hand to hand.

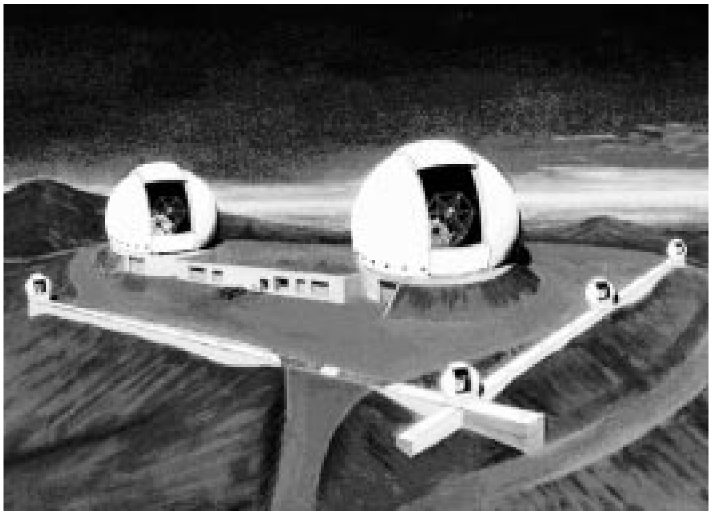
SIM will be launched early in the next decade and will map the wobbles of nearby stars as their paths weave across the sky, providing indirect evidence that these stars have planets orbiting around them and exerting their gravitational pull. From these observations, astronomers will be able to infer the presence of planets as small as the Earth itself. SIM will also produce advances in many other branches of astronomy. It will triangulate the positions of individual stars anywhere in our galaxy and even in some nearby galaxies. These measurements will establish the first rungs of the cosmic distance ladder by which astronomers infer the distances to all objects in the Universe.

Space Infrared Telescope Facility (SIRTF)

Starting in 2001, the operations of the Space Infrared Telescope Facility, (SIRTF) will overlap the



Space Infrared Telescope Facility



Keck Interferometer

operations of Hubble and AXAF and complement their observations. SIRTF's sophisticated cooled optics will increase our knowledge of planet, star and galaxy formation. SIRTF will answer questions about the dust clouds surrounding stars like our sun --- clouds that might mark the sites of developing planets.

The launch of SIRTF will mark the debut of several technological innovations critical to NGST and TPF missions. These developments include a unique solar orbit (trailing the Earth as it moves around the Sun), state-of-the-art infrared cameras, a new, lightweight low temperature beryllium telescope, and a telescope cooling system that reduces the mass and costs of the systems needed to maintain the low temperatures crucial to infrared observations.

The National Academy of Sciences has designated SIRTF as the highest priority mission for U.S. astronomy in the 1990s.

The Keck Interferometer

Well before the launch of the Terrestrial Planet Finder, we will be able to find planets with masses as small as that of Uranus orbiting around nearby stars by watching the motions of their parent stars. NASA has announced plans to link the world's two largest ground-based telescopes, the 400-inch Keck telescopes atop Mauna Kea in Hawaii, to function together as an interferometer. These two giant telescopes, assisted by four smaller "outrigger" telescopes spread over an area slightly smaller than a football field, will be able to watch the dance of nearby stars under the influence of planets which may be orbiting them. The Keck interferometer will also make images of the faint dust clouds around nearby stars that might be signposts of planetary systems. Scheduled to begin operations in just three years, the Keck system will lay much of the technological groundwork for subsequent space interferometers. It will pave the way for the other long-term Origins missions.

More information on NASA's Origins Program is available from its home page at http://www.hq.nasa.gov/office/oss/origins/Origins.html .

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