NASA Facts

National Aeronautics and
Space Administration

Goddard Space Flight Center
Greenbelt, Maryland 20771
(301) 286-8955

FS-2002-07-044-GSFC

The Next Generation Space Telescope in Search of Our Origins

Astronomers are peering farther and farther out in space and back in time to study objects that existed when our universe was still very young. Our current understanding of how the universe formed and evolved is remarkably clear at the extreme ends of time. That is, we have a good understanding that the universe is between 13 and 14 billion years old, and we have seen some distant objects as they were when the universe was only one or two billion years old. We understand what the universe was like when it was quite young, less than one million years old, based on measurements of the cosmic microwave background radiation and on theoretical studies of high-energy particle physics. The middle ground, however, between one million and one billion years after the beginning, is completely unobserved. It is during this time period that the structures we see today, stars and galaxies, began to form.

Astronomy in the last 50 years has made wondrous discoveries, expanded our understanding of the universe and opened humanity's vision beyond the visible portion of the electromagnetic spectrum. Our knowledge of how the cosmos was born and how many of its phenomena arise has grown exponentially in just one human lifetime. In spite of these great strides there remain fundamental questions that are largely unanswered. To further our understanding of the way our present universe formed following the Big Bang requires a new type of observatory with capabilities currently unavailable in either existing ground-based or space telescopes. NASA is developing the Next Generation Space Telescope (NGST) to observe the first stars and galaxies in the universe. This grand effort will help to answer fundamental questions that have been posed to NASA's Space Science program:

1. How do galaxies form and evolve?
2. How do stars and planetary systems form and interact?
3. How did the Universe build up its present elemental/chemical composition?
4. What is dark matter?

The NGST is planned for launch in the year 2010. The NGST effort is led by NASA's Goddard Space Flight Center in Greenbelt, Md. for the Office of Space Science at NASA Headquarters in Washington, D.C.

GALAXY EVOLUTION

Galaxies are dynamic systems that change with time. The NGST will be the only facility able to trace the complete evolution of galaxies from their creation to the present day. The first galaxies probably formed when the universe was several hundred million years old. NGST will

be capable of studying these early galaxies, and then by making a census of galaxies with different ages, astronomers will be able to learn how galaxies evolve with time.

EVOLUTION OF STARS AND PLANETARY SYSTEMS

The Hubble Space Telescope (HST) finds stars being born in the constellation of Orion and the Eagle nebula, but they are hidden inside dusty cocoons. The NGST will use infrared light to see deeper inside the dust clouds and measure their structures.

By mapping the light from dust grains orbiting around stars, the NGST will find evidence of the formation of planetary systems, some of which may be similar to our own solar system. The NGST will have unprecedented sensitivity to faint dust clouds around nearby stars. These dust disks are expected to be much brighter than the planets themselves, and their detailed shapes could reveal the influence of any planets that may be present.

LIFE CYCLE OF MATTER IN THE UNIVERSE

Essentially all elements heavier than helium, including the constituents of our own bodies, have been manufactured in stars. The NGST will be the first telescope to observe stars and galaxies made out of the pristine material created in the Big Bang before it began its cycling through stars. The build-up of chemical elements in the universe is generally understood: primordial matter (hydrogen and helium) condenses into stars, which convert hydrogen to helium and helium into heavier elements like carbon, oxygen and nitrogen. Through stellar winds or supernovae this enriched matter is ejected back into space, and recycled to form new generations of stars and planets.

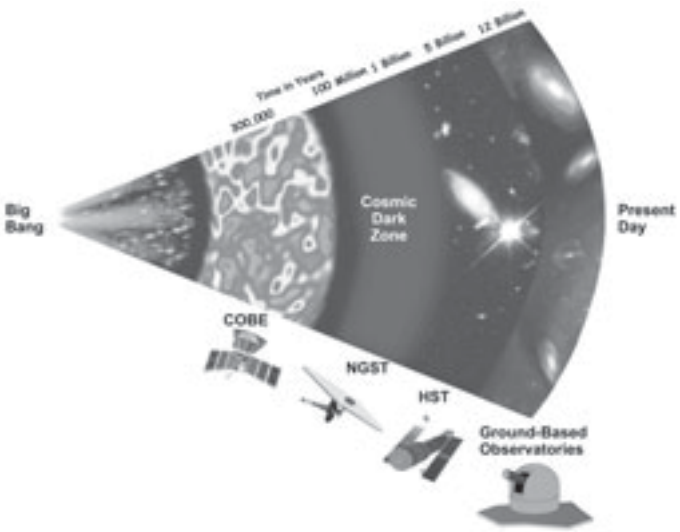

Illustration of what space-based and land-based observatories can see.

The NGST will observe the first stages of this life cycle. It will see the first galaxies, the first stars, and the first supernovae, and thereby witness the creation of the heavy elements.

THE ROLE OF DARK MATTER

Our understanding of how the first stars and galaxies emerged from the hot plasma created by the Big Bang is not complete without a better understanding of dark matter, a mysterious substance that played a role in their formation and evolution. Although dark matter has never been directly observed, its presence is inferred because of its gravitational effect on other luminous objects, and there is at least 10 times as much dark matter as ordinary matter. NGST will measure the distribution of dark matter by measuring the gravitational bending of light rays as they pass near concentrations of matter. By measuring the gravitational effects of dark matter in the largest structures we know - galaxies and large groups of galaxies - NGST will improve out understanding of the nature and distribution of dark matter and its influence in shaping our universe.

LOOKING BACK IN TIME LOCALLY

NGST will reveal much about the history of our own Milky Way galaxy and dozens of our galactic neighbors. NGST will measure the brightness and colors of individual stars at great distances and in heavily crowded regions, and the faintest stars in the galactic bulge. Astronomers can then determine the ages and original properties of globular clusters, thought to contain the oldest stars in the galaxy. Closer to home, astronomers will observe white dwarf stars that have nearly completed their nuclear life and exhausted their hydrogen, revealing the ages of stars and the history of element production in our own Galaxy.

POST HUBBLE

The Next Generation Space Telescope will be designed to use imaging and spectroscopy in the infrared. NGST will be capable of detecting radiation whose wavelength lies in the range from 0.6 to 28 microns, but will be optimized for the 1 to 5 micron region. The NGST will be able to see objects that are much, fainter than those currently studied with large ground-based infrared telescopes (such as the Keck Observatory or the Gemini Project) or the current generation of space-based infrared telescopes (HST-NICMOS or SIRTF), and will do so with a spatial resolution (image sharpness) comparable to the Hubble Space Telescope.

The NGST will have a primary mirror diameter of at least six meters (20 feet) in diameter. The larger mirror diameter gives NGST much more light gathering capability than HST.

DISTANT ORBIT

NGST will be placed far from the Earth using an expendable launch vehicle. Unlike Hubble, NGST will not be serviced because it will be too far away to retrieve. NGST will be placed in orbit around the second Lagrange Point (L2) of the Sun-Earth system, which is 940,000 miles, or 1.5 million kilometers from the Earth. It will take about three months for NGST to reach its destination.

The most important advantage of this orbit is that a single-sided sun shield, on only one side of the observatory, can protect the telescope from heat from both Sun and Earth. As a result, the telescope will cool to very low temperatures without the use of complicated refrigeration equipment. These low temperatures are required to prevent the telescope's own heat radiation from exceeding the brightness of the distant astronomical objects. The infrared detectors in the instruments will operate at temperatures below minus 370 degrees Fahrenheit or 50 degrees Kelvin. NGST will be so far away from Earth that the residual atmosphere will not affect it, it will almost never pass through the Earth's shadow, the Earth will never shine on the telescope mirror, and there will be no complex activities to protect NGST from the Earth and its effects. This orbit allows greatly simplified operations and targeting requirements compared with HST.

INSTRUMENTS

The new telescope will carry a near-infrared camera, a multi-object spectrometer, and a mid-infrared camera/spectrometer. A science team led by the University of Arizona, Tucson, has been selected to provide the near-infrared camera, in partnership with Canadian scientists sponsored by the Canadian Space Agency. The Near IR Spectrometer will be provided by the European Space Agency, using detectors and a microshutter array provided by NASA. A partnership of NASA (JPL) and a consortium of European institutions organized by ESA will build the mid IR instrument. The Fine Guidance Sensor will be provided by the Canadian Space Agency.

OPTICS

One of NGST's most notable technological achievements will be its "eyes," the system of mirrors and support trusses that collect light and direct it to the telescope's onboard instruments for imaging and analysis. The most innovative component of the system is the telescope's primary mirror. Because NGST will be launched on a medium-sized rocket, engineers have to be creative in developing a mirror that will fit inside the rocket's relatively tight quarters. They have chosen a segmented mirror design to save room. Before and during launch, the mirror will be folded up. Once the telescope is placed in its orbit, ground controllers will send a message telling the telescope to unfold its mirror segments.

The Next Generation Space Telescope will be constructed using advanced optical technology that produces extremely lightweight mirrors. Such mirrors are required for this and future telescopes. Mirrors must become larger to collect light from fainter, more distant objects. Since the cost of launching satellites is a strong function of their mass, lighter mirrors mean lower launch costs. Currently, there are several mirror studies being conducted by NASA and industry partners.

CRYOGENIC ACTUATORS

The primary mirror for NGST will be too large to retain its perfect optical shape through material stiffness. The reflective surface will be computer controlled via actuators, which can adjust the shape of the mirror to give high quality, sharp images. These actuators will need to work at the extremely cold temperatures at which NGST is expected to operate (~30-100 Kelvin). The primary requirements for these actuators are the capability of operating at cryogenic temperatures and extremely fine position knowledge and control.

SPACE vs. GROUND-BASED OSERVATORIES

The best ground-based observatories are capable of making observations in the near infrared and in selected bands in the mid-infrared but must accommodate the atmosphere's infrared glow. Although such telescopes and those coming in the future will conduct forefront astronomical research, they will not have the complete infrared wavelength coverage of NGST. Ground-based telescopes will always suffer some blurring of images due to the Earth's atmosphere turbulence. The blurring can be corrected over small regions in an image, but only by going above the Earth's atmosphere can sharp images over wide fields of view be achieved.

NGST PROJECT TEAM

NASA's Goddard Space Flight Center in Greenbelt, Md. will manage NGST's development by a NASA-wide team and a prime contractor. The Space Telescope Science Institute in Baltimore will operate the observatory much as it does the Hubble Space Telescope. The European Space Agency and the Canadian Space Agency have agreed to contribute fifteen percent and five percent respectively to the mission development effort. The astronomy community, represented by the Science Working Group, will help define science requirements and build science instruments.

WEBSITES

To find out more information on the Next Generation Space Telescope, consult the following websites:

http://www.ngst.nasa.gov
http://nextgen.stsci.edu