

# NASA Facts

National Aeronautics and  
Space Administration

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## Spitzer Space Telescope

The Spitzer Space Telescope is the fourth and final element in the National Aeronautics and Space Administration's family of orbiting "Great Observatories," which includes the Hubble Space Telescope, the Compton Gamma-Ray Observatory and the Chandra X-Ray Observatory. This new infrared observatory is also an important scientific and technical bridge to NASA's Origins Program – an attempt to address such fundamental questions as "Where did we come from? Are we alone?"

### Turning Up the Heat

All objects in the universe with temperatures above absolute zero – corresponding to zero degrees Kelvin, which is about -273 Celsius, or -460 Fahrenheit – emit some infrared radiation, or heat. Infrared wavelengths lie beyond the red portion of the visible spectrum, and are invisible to the human eye. Trying to detect weak infrared light from astronomical objects is a tricky business because telescopes produce their own heat, referred to as infrared noise.

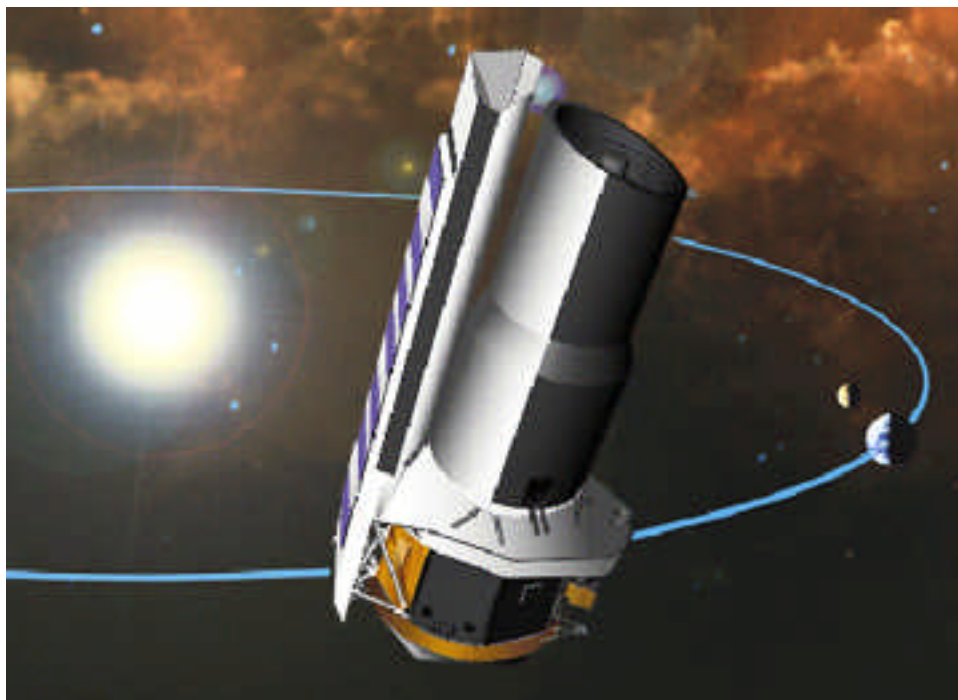
So astronomers have to chill their telescopes and instruments to temperatures hovering just slightly above absolute zero to enable detection of any incoming infrared radiation. And since most infrared light emitted by celestial objects is absorbed by Earth's atmosphere, scientists look to orbiting telescopes to provide the highest sensitivity at infrared wavelengths.

The Spitzer Space

Telescope will capture those celestial objects and phenomena that are too dim, distant or cool to study by other astronomical techniques.

### The Infrared 'Great Observatory'

NASA's Great Observatories give astronomers an orbiting "toolbox" that provides multi-wavelength studies of the universe. The Hubble Space Telescope has delivered a wealth of spectacular images and has fundamentally changed perceptions of the cosmos. Observing at optical, ultraviolet and near-infrared wavelengths, Hubble will continue operating through



the year 2010.

The Compton Gamma-Ray Observatory, launched in 1991, studied extremely high-energy phenomena in the universe such as solar flares, quasars and cosmic-ray interactions, before its mission ended in 1999.

The Chandra X-Ray Observatory, launched in 1999, currently examines energetic phenomena such as supernovas and black holes, and will operate through at least 2009.

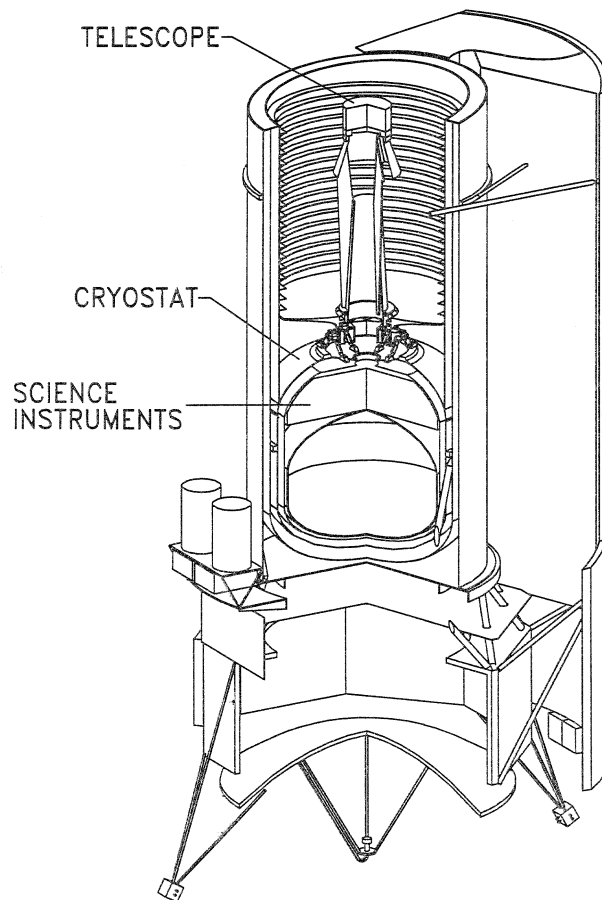
In the summer of 2003, the Spitzer Space Telescope joined this spectacular suite of space instruments and provide complementary and synergistic observations of some of the many cosmic dramas that have caught the attention of the astronomical community. The observatory brings a fresh vantage point on processes that have until now remained mostly in the dark, such as the formation of galaxies, stars and planets.

The spacecraft consists of an 85-centimeter-diameter (33-inch) telescope and three cryogenically cooled science instruments incorporating state-of-the-art, large-format infrared detector arrays. The observatory is capable of studying the cosmos at infrared wavelengths from 3 to 180 microns (a human hair is about 50 microns in diameter).

Within our Milky Way galaxy, the infrared telescope will discover and characterize dust discs around nearby stars, thought to be signposts of planetary system formation. It will also provide new insights into the birth process of stars, an event normally hidden behind veils of cosmic dust. Outside our galaxy, the new infrared facility will help astronomers uncover the engines – thought to be galaxy collisions or black holes – powering ultra-luminous infrared galaxies. The observatory will also probe the birth and evolution of galaxies in the early and distant universe. The telescope is designed for a lifetime of five years, which should provide substantial improvements in capability over previous orbiting infrared telescopes.

### Drifting into Deep Space

When the National Academy of Sciences declared the Spitzer Space Telescope (formerly named the Space Infrared Telescope Facility) the highest-priority new initiative in astronomy and astrophysics for the 1990s, the mission's total development cost totaled roughly \$2.2 billion. However, the observatory has



since undergone radical changes in design to meet evolving cost constraints. Moreover, ongoing advances in the technology of infrared detectors, coupled with innovative choices in orbit and the design of cryogenic systems, have maintained the scientific vitality of the telescope at roughly one-third the original cost estimate.

One major breakthrough was the clever choice of orbit. Instead of orbiting Earth itself, the observatory trails behind Earth as it orbits the Sun. The spacecraft drifts slowly away from our planet into deep space, circling the Sun at a distance of about 1 astronomical unit (the mean Earth-Sun distance of 150 million kilometers, or 93 million miles). The telescope drifts away from us at about 1/10th of one astronomical unit per year. This unique orbital trajectory keeps the observatory away from much of Earth's heat, which can reach 250 Kelvin (-23 Celsius, or -10 Fahrenheit) for satellites and spacecraft in more conventional near-Earth orbits. The Spitzer Space Telescope will operate in a more benign thermal environment of about 35 Kelvin (-238 Celsius, or -397 Fahrenheit). With this new approach, mission designers allow

Mother Nature to do much of the work in keeping the observatory properly chilled.

Moreover, an Earth-trailing orbit will protect the observatory from Earth's radiation belts, thereby reducing the deleterious effects on the observatory's extremely sensitive detectors.

### **A New Way to Chill**

The observatory's unique orbit enables a second major technical innovation: what engineers call "warm-launch architecture." Previous space-bound infrared observatories enclosed the entire telescope assembly within a gigantic cryostat – akin to a large thermos bottle – containing a cryogen, or coolant, to maintain the necessary chill. With this new infrared telescope, only the science instrument chamber and a compact cryostat will be cold at launch, chilled to about 1.5 Kelvin (-272 Celsius, or -457 Fahrenheit). Following launch from Cape Canaveral Air Force Station in Florida, the spacecraft cooled in the deep recesses of space for about five weeks. The observatory uses the vapor from the boil-off of its cryogen fluid to cool the telescope assembly down to its optimal operating temperature of 5.5 Kelvin (-268 Celsius, or -450 Fahrenheit).

This innovative approach allowed a dramatic reduction in the amount of liquid helium cryogen, with huge savings in launch mass and cost. Carrying only 360 liters of liquid helium, the observatory is expected to achieve a working lifetime of about five years, much longer than past infrared space observatories. The launch mass is further reduced by using lightweight optics, including mirrors and supporting structures made out of the metal beryllium. The entire observatory, including cryogen, weighs 950 kilograms, or about one ton.

### **New Vision**

With the help of NASA's sponsorship, industrial fabricators and university researchers worked together to reduce the electronic noise and increase the sensitivity and performance of infrared detectors. The great leap in light sensitivity has been matched by a dramatic increase in the size of detector arrays. Less than two decades ago the first orbiting infrared observatory had only 62 detectors, but the new observatory will aim nearly 300,000 "eyes" on celestial targets.

### **Seeing the Light**

The infrared energy collected by the observatory will be studied and recorded by three main science instruments: an infrared array camera, an infrared spectrograph and a multiband imaging photometer.

The infrared array camera enables imaging at near- and mid-infrared wavelengths. Astronomers use this general-purpose camera for a wide variety of scientific research programs.

The infrared spectrograph allows for both high- and low-resolution spectroscopy at mid-infrared wavelengths. Spectrometers spread light out into its constituent wavelengths, called a spectrum. Astronomers then scrutinize spectra for emission and absorption lines – the fingerprints of atoms and molecules. This spectrometer has no moving parts.

The multiband imaging photometer provides imaging and limited spectroscopic data at far-infrared wavelengths. It has three detector arrays, one each for a pre-specified range of wavelengths. The only moving part in the imaging photometer is a scan mirror for efficiently mapping large areas of sky.

### **'The Far, the Cold and the Dusty'**

The telescope's science team quips that the mission will seek "the old" (the earliest stars and galaxies), "the cold" (brown dwarfs and circumstellar discs) and "the dirty" (dust-obscured processes such as star and planetary formation). The observatory's powerful combination of highly sensitive detectors and long lifetime will allow scientists to view these types of objects and phenomena that have managed to elude astronomers using other astronomical methods.

The vast majority of the telescope's observing time is available to the general scientific community through peer-reviewed proposals. The observatory's design was driven by the goal of making major scientific contributions in the following major research areas:

- **Protoplanetary and Planetary Debris Discs:**

These are flattened discs of dust that surround many stars. Protoplanetary discs include large amounts of gas, and are presumed to be planetary systems in the making. Planetary debris discs have most of their gas depleted, and represent a more mature planetary system. The remaining dust disc may include gaps

indicative of fledgling planetary bodies. By observing dust discs around stars at various ages, the new infrared facility can trace the dynamics and chemical history of evolving planetary systems, and provide statistical evidence of planetary system formation. Such information may also help astronomers chart the history of our solar system, while providing target lists for future planet-searching missions.

- **Brown Dwarfs:** These curious objects do not possess enough mass to ignite nuclear fusion reactions that power true stars; in fact, astronomers have described them as failed stars. Brown dwarfs are larger and warmer than the planets found in our solar system. At one time just a theory, scientists have begun to detect these long-sought objects. If numerous enough, brown dwarfs may provide an appreciable fraction of the elusive dark matter, or "missing mass," thought to permeate the universe. Since they are much cooler than the Sun, brown dwarfs glow primarily in the infrared. The Spitzer Space Telescope will provide critical data on their abundance and character.

- **Ultra-Luminous Infrared Galaxies:** Many galaxies emit more radiation in the infrared than at all other wavelengths combined. These so-called ultra-luminous infrared galaxies might be powered by intense bursts of star formation, stimulated by colliding galaxies or by central black holes. The infrared telescope will trace the origins and evolution of ultra-luminous infrared galaxies out to cosmological distances.

- **The Early and Distant Universe:** The space observatory will probe galaxies at the cosmic fringe. These objects are so remote that the radiation they once emitted has taken billions of years to reach Earth. A consequence of an expanding universe, these faraway galaxies are speeding away from us so rapidly that most of their optical and ultraviolet light has "red-shifted" into the infrared. The telescope will be able to examine these first stars and galaxies, and thereby clue us into the character of the infant universe.

Apart from these important research areas, the Spitzer Space Telescope's near-infrared instrument will peer through obscuring dust that cocoons newborn stars, both in the nearby universe and the center of our Milky Way Galaxy. The observatory will also

contribute to studies within our solar system, such as inspection of objects in the Kuiper Belt beyond the orbit of Pluto, and the chemical composition of comets, asteroids and other small interplanetary bodies.

History has repeatedly shown that any giant leap in astronomical capability – as the new infrared telescope will offer – is certain to provide serendipitous discoveries of unanticipated phenomena.

## A Bridge to the Future

The imaging and spectroscopic results from the Spitzer Space Telescope will create a solid foundation for future observatories to build upon. The James Webb Space Telescope, a next-generation space observatory envisioned as the successor to the Hubble Space Telescope, will hold a mirror more than seven times the area of Hubble's reflector, and will be designed to operate at short- and medium-infrared wavelengths. The Spitzer Space Telescope's engineering with cryogenic, lightweight mirrors and radiative cooling are critical to the eventual success of the Webb telescope.

NASA has future plans for the Terrestrial Planet Finder, a space telescope designed to detect and characterize Earth-like planets around nearby stars. In order to find individual planets this telescope will require advance knowledge about the extent and nature of dust around candidate stars. The Spitzer Space Telescope's study of planetary debris discs will provide vital data for eventual Terrestrial Planet Finder scientists hoping to glimpse an Earth-like world.

## Heating Up the Web

For more information on the Spitzer Space Telescope mission visit the mission's home page at <http://www.spitzer.caltech.edu/>.

The Spitzer Space Telescope mission is managed by NASA's Jet Propulsion Laboratory, Pasadena, Calif., for NASA's Office of Space Science, Washington. Science operations are conducted at the Spitzer Science Center at the California Institute of Technology in Pasadena. Major partners are Goddard Space Flight Center, Greenbelt, MD, Lockheed Martin Corporation, Denver, Colo., and Ball Aerospace Corp., Boulder, Colo.

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