NASA Facts

National Aeronautics and
Space Administration

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WIDE-FIELD INFRARED EXPLORER (WIRE): SURVEYING STARBURST GALAXIES

The Scientific Mission

One goal of NASA's Origins Program seeks to understand how life arose on Earth, and to determine if life exists anywhere else in the universe. In order to understand the origin of life, it is necessary to understand the origin of stars because stars, such as our own Sun, make life possible on planets such as Earth. The goal of NASA's Wide-Field Infrared Explorer (WIRE) spacecraft is to understand the history of star formation in the universe.

Current observations suggest that stars and their planetary systems form when massive interstellar clouds of gas and dust collapse. Thus, most star-forming regions are shrouded by dusty clouds that block the visible and ultraviolet light emitted by young stars and are warmed by the process. This makes the star formation process very complicated to interpret using ordinary visible light telescopes. However, the warm dust can emit prodigious amounts of infrared light, which the WIRE telescope can detect. Light of this type is not visible to the human eye, and is perceived as heat.

Although the star formation process is brief by astronomical time scales, it is extremely long compared to human experience, lasting perhaps a few tens of millions of years. No human observation could ever view a single star through all its birth phases. Thus, WIRE will make observations of vast collections of stars in different phases, with the intention of providing enough data to assemble a history of stellar formation. This is similar to how botanists study tree growth. It would be impractical to observe a single tree throughout its entire lifetime, so botanists survey an entire forest, expecting to find different examples of a certain species at different stages in its life cycle. WIRE will survey a "forest" of star-forming regions by observing entire galaxies rather than individual stars. It will take the star formation inventory of 100,000 galaxies within a region of the sky equal to 5,000 times the area of the full moon, or between two and three percent of the celestial sphere. This large area may allow WIRE to detect rare objects or new phenomena within its brief, 4-month planned mission.

WIRE will concentrate its observations on starburst galaxies, extremely bright galaxies that are producing new stars at ten times the rate of typical galaxies. It will also search for ultra-luminous galaxies, very energetic, possibly extremely distant galaxies with intense star formation. WIRE will examine the remote universe to determine the large-scale distribution of galaxies, which will be used to test competing theories of galaxy evolution.

Some of the ultraluminous galaxies may be billions of light years away, possibly representing the first galaxies to form.

WIRE will also make observations closer to home. It will look into the star-forming regions in our own galaxy. It will also help to discover the

structure of our galaxy. The galaxy is shaped like a disk, and we are located near one outer edge. This makes it difficult to determine the galaxy's structure, because dust clouds in the inner portions of the disk block our view. Since WIRE can see through those clouds, it will help determine galactic structure.

WIRE will search for a kind of "failed" star, called a brown dwarf. Brown dwarfs are relatively small objects that shine faintly, mostly in infrared light. However, they do not shine for the same reasons that a normal star shines. A normal star shines because of energy supplied by nuclear fusion reactions in its central core. Brown dwarfs, at only about 80 times as massive as Jupiter, have too little mass to sustain nuclear fusion reactions in their cores. Instead, they glow dimly with the heat left over from contraction begun during their formation. WIRE should be able to detect their feeble light out to a distance of about 35 light-years away.

When a star forms from a collapsing cloud, it often is surrounded by a disk of material from that cloud. It is believed that planets form out of the material in these disks. The circumstellar disks absorb light from the star and radiate it again as infrared light. WIRE will thus be able to scan stars for circumstellar disks, possibly finding clues to planet formation.

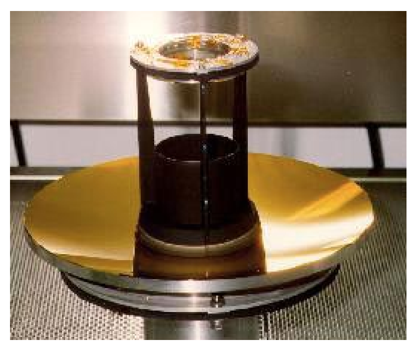
WIRE will look within our own solar system as well. It will take an inventory of main belt asteroids to determine if there is an increase in the number of smaller ones (less than 1.25 miles across) as predicted by some theories. It will also observe comet trails, dust that has been ablated from comets as their orbit takes them close to the Sun and exposes them to strong solar radiation. As the Earth progresses in its orbit, it occasionally intersects a comet trail. The result is often a spectacular meteor shower, as the high-speed dust grains burn up harmlessly in our atmosphere. However, as our satellite constellation grows, these showers become an increasing concern. If the shower is particularly intense, the satellites could be "sandblasted" by the dust. Although less common, impacts with the larger grains pose a greater threat because the impact vaporizes the grain and the tiny impact area on the satellite, forming a cloud of electrically charged gas called plasma that can short-circuit sensitive electronic components.

The Instrument

The WIRE instrument is provided to Goddard Space Flight Center (GSFC) by NASA's Jet Propulsion Laboratory (JPL). The WIRE instrument consists of a 30-centimeter aperture (12.5-inch) Cassegrain telescope with no moving parts and a field of view about the size of the full moon.

The telescope is provided by Utah State University's Space Dynamic Laboratory and is enclosed within a two-stage, state-of-the-art, solid-hydrogen cryostat designed and manufactured by Lockheed-Martin Advanced Technology Center. The WIRE cryostat uses the sublimation (transition directly from solid to gas) of frozen hydrogen to cool the telescope. The cryostat is designed like a thermos bottle, using a vacuum space between layers of insulation, to minimize heat flow to the inside. The telescope mirrors are cooled to less than 13 Kelvin (K) (-436 F) and the focal plane arrays are cooled to less than 7 K (-447 F) using only 4.5 kilograms (9.9 pounds) of solid hydrogen. The telescope must be cold so that its own infrared light doesn't overwhelm the light that it is trying to detect from space.

The Boeing/Rockwell long-wave infrared detectors used by WIRE provide a two-color view of science targets at infrared wavelengths of 12 and 25 microns (a micron, mm, is one millionth of a meter). Infrared light has a wavelength longer than the light we can see. We can feel infrared radiation—the warmth of the Sun or a fire is caused by the infrared light being absorbed by our skin. Visible light has a wavelength between .4 mm and .7 mm, and infrared light has a wavelength between .7 mm and 1000



Telescope mirror assembly.

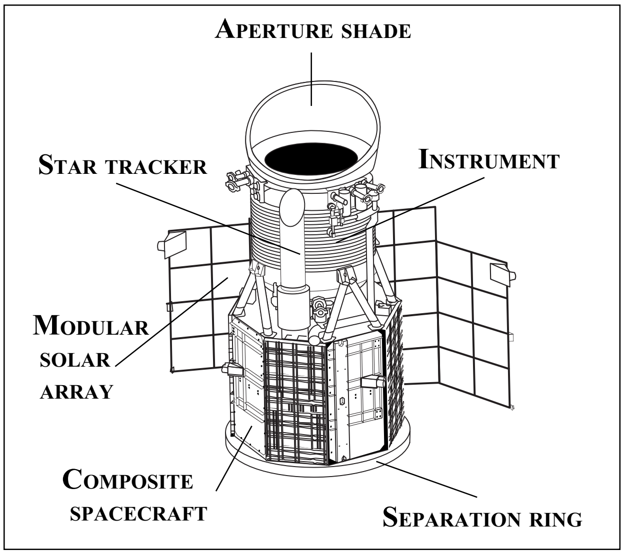
mm. A television remote control typically operates in the near infrared around 1 mm. Objects at room temperature emit infrared light with a peak around 10 mm. WIRE is studying objects which are colder than that—25 mm corresponds to a temperature of about 116 K (-251 F).

The entire WIRE instrument requires only 28 watts of power and a relatively low average science data rate (11,000 bits per second) to complete its science objectives.

The Spacecraft

Once the WIRE instrument was delivered to GSFC in Greenbelt, MD, it was integrated onto a three-axis-stabilized spacecraft designed and built by the GSFC Small Explorer (SMEX) Project Team. The spacecraft makes use of state-of-the-art structural composites and modular solar array technologies to minimize mass, as well as an elaborate Attitude Control System (ACS) to permit very stable, repeatable astronomical observations to be made over extended periods of time.

The WIRE structure, built by Composite Optics Incorporated in San Diego, CA, is composed of flat pieces of graphite epoxy material bonded into



The WIRE observatory.

strong, light-weight, ribbed components. The electronics boxes are bolted to the inside face of the equipment panels, which are around the outside of the spacecraft. Special high-thermal-conductivity composite spreads the heat on each equipment panel, controlling the temperature of the attached electronics box. The solar panel structure is also composite with individual modules bonded to an overall composite frame. The structure supports all of the spacecraft components, including the 188-lb instrument on top, and it must be strong enough to support launch loads, which increase the weight of all components by more than a factor of 10. The entire spacecraft weighs 563 lbs, but the structure weighs only 57 lbs, thanks to composite materials.

The ACS uses a star tracker and gyros for fine measurement of the spacecraft pointing. Ultra-smooth-spinning reaction wheels control the attitude with a stability of 0.0017 degrees, creating very sharp images of the starburst galaxies. The four reaction wheels spin continually throughout the mission. To point the instrument toward a new target, the spacecraft changes the speed of the wheels, which causes an equal and opposite reaction in the spacecraft body. The spacecraft again changes the speed of the wheels to stop at the next target. To counteract small external disturbances that would eventually cause the spacecraft to tumble, such as atmospheric drag, the ACS uses electromagnets that push against the Earth's magnetic field. The actuators are controlled by software running on a radiation-tolerant 80386 processor with 387 math coprocessor. All electronics that fly in space must be able to handle occasional impacts of high-energy protons as well as the gradual accumulation of hits from lower energy particles.

To communicate with the ground, the spacecraft uses a radio that operates in the microwave frequency band. The two communication antennas, which are located on the ends of the solar arrays, provide coverage no matter where the spacecraft is pointed. Ground stations in Poker Flat, AK; Wallops Island, VA; and McMurdo, Antarctica, relay data between the spacecraft and the control center at GSFC. The spacecraft is in view of any ground station for only about 10 minutes, but the two polar ground stations provide two contacts for almost every one of the 90-minute orbits. After the initial checkout of the spacecraft, which takes a couple of weeks, only two contacts per day are necessary to retrieve all of the data collected during the day. The spacecraft stores data in its 240 Mbyte recorder until it has contact with a ground station.

The solar arrays generate all of the electrical power the spacecraft needs directly from the sunlight. A 28-volt, nickel-cadmium, rechargeable battery, which weighs 26 lbs, provides power during initial acquisition after launch and during any eclipse periods, when solar power is unavailable.

WIRE's Orbit

After the WIRE spacecraft is integrated with the Pegasus XL launch vehicle and loaded with solid hydrogen at Vandenberg Air Force Base, CA, WIRE will be carried under the belly of a Lockheed L-1011 aircraft to an altitude of approximately 39,000 feet. From this altitude, the Pegasus rocket will be launched and subsequently place the WIRE spacecraft into a nearly polar, circular orbit 540 kilometers (335 miles) above the Earth.

WIRE will be launched from a Pegasus XL similar to the one shown here on an L-1011 aircraft.

Quick Mission Facts

Launch Date: February 1999

Launch Vehicle: Orbital Sciences Corp. Pegasus XL Rocket

Launch Site: Western Range/VAFB, CA

Orbit: 540-km circular, 97.56-degree inclination

Mission Duration: 4 months

Spacecraft Mass: 256 kilograms

Total Power: 135 watts

WIRE and the SMEX Program

NASA's SMEX program provides frequent flight opportunities for highly focused and relatively inexpensive space science missions. SMEX spacecraft are 180–250 kilograms with orbit average power of 50–200 watts. Each mission is cost-capped for design, development, and operations through the first 30 days in orbit. While using modern technology and management techniques, the program is dedicated to the 40 year Explorer program tradition of service to the space science community.

WIRE (the fifth SMEX mission) was one of two missions chosen for development and flight by NASA in 1994 for SMEX Mission Set #2 under the space agency's SMEX Program. The WIRE observatory was accomplished through a partnership between GSFC and JPL.

WIRE and the Origins Program

Have you looked at the night sky and asked yourself: Where did all this come from? How did we get here? Our generation is privileged—if we accept the challenge—to have the opportunity to answer these timeless questions asked around the ancient campfires and in contemporary classrooms today. NASA's Origins Program will search for clues to help us find our cosmic roots including answer to questions such as:

How did the first galaxies form?
How do stars and planetary systems form?
Are there any planets outside our solar system that are capable of sustaining life?
How did life originate on Earth?
Is there life (however primitive or evolved) outside our solar system?

For the first time ever in our history, we are on the verge of having the technological capability to seek the answers to these age-old questions. We can build telescopes capable of looking far back in time, collecting the faint light from the first-ever galaxies. We can cleverly combine the light gathered from several small telescopes spaced far apart and create images with the equivalent resolution of a telescope the size of a football field. With this technique, called interferometry, we can block the light from distant stars so that we will be able to see the much smaller and dimmer planets orbiting them. Soon we will be able to do this outside the blurring atmosphere, where the vision of these observatories is far clearer.

Over the course of the next two decades, the Origins Program will utilize the best minds in academia, industry, and NASA to develop the technologies that will enable putting in space a succession of increasingly sophisticated telescopes, each building on scientific and technological achievements of preceding missions. Augmented with ground-based observatories and research and analysis, NASA's Origins Program will give our civilization a better sense of the universe around our place and us in it.

It is anticipated that scientific information from the WIRE mission will provide meaningful input to NASA's Origins Program and may be able to help answer some of these fundamental questions about out universe.

Educational Outreach

As part of NASA's education outreach program, the WIRE mission is participating in the Cooperative Satellite Learning Program (CSLP) through its association with various high schools in Maryland and Pennsylvania. The CSLP students will follow the progress of the mission via the World Wide Web and one-on-one contact with GSFC engineers.

WIRE Website: http://sunland.gsfc.nasa.gov/smex/wire/