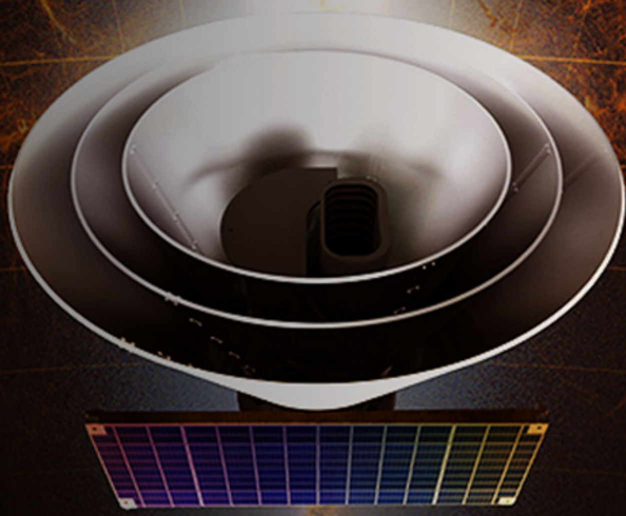
National Aeronautics and Space Administration

SPHEREx

Press Kit / February 2025



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Introduction

SPHEREx Press Kit

NASA's latest space telescope, SPHEREx, will map the universe like none before it, providing a big-picture view that will illuminate the origins of our universe, galaxies within it, and life's key ingredients in our own galaxy. Short for Spectro-Photometer for the History of the Universe, Epoch of Reionization and Ices Explorer, SPHEREx will observe hundreds of millions of galaxies and other objects during its two-year mission, mapping the cosmos in wavelengths invisible to the human eye. The mission is targeting a late-February 2025 launch from Vandenberg Space Force Base in California. SPHEREx is managed by NASA's Jet Propulsion Laboratory in Southern California for NASA's Astrophysics Division within the Science Mission Directorate in Washington. The principal investigator is based at Caltech in Pasadena, California, which manages JPL for NASA.

8 Things to Know About SPHEREx

Space telescopes like NASA's Hubble and Webb have zoomed in on many corners of the universe to show us planets, stars, and galaxies in high resolution. But some questions can be answered only by looking at the big picture. Using 102 color filters to map the entire sky, what new discoveries could SPHEREx help unlock? Here are eight key facts about the mission.

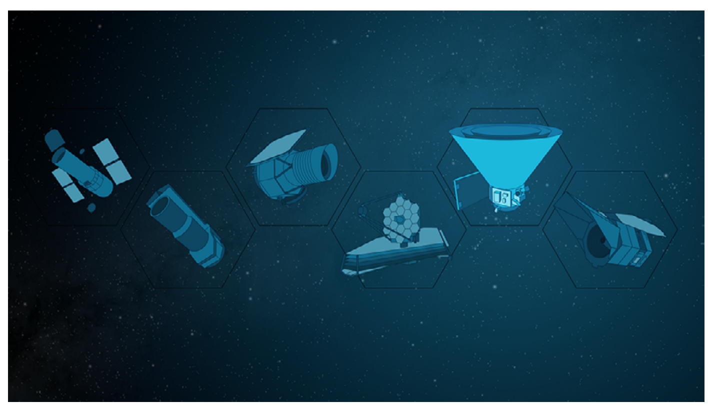
1. The SPHEREx mission will help answer some of the biggest questions in astrophysics.

The mission contributes to NASA's key scientific goals to discover the secrets of the universe and search for life beyond Earth. Its all-sky map will help scientists answer major questions about why the large-scale structure of the universe looks the way it does, how galaxies form and evolve, and the origins and abundance of water and other key ingredients for life in our galaxy.

Star cluster Trumpler 14. Credit: NASA/ESA | Full Image

2. It adds unique strengths to NASA's fleet of space telescopes.

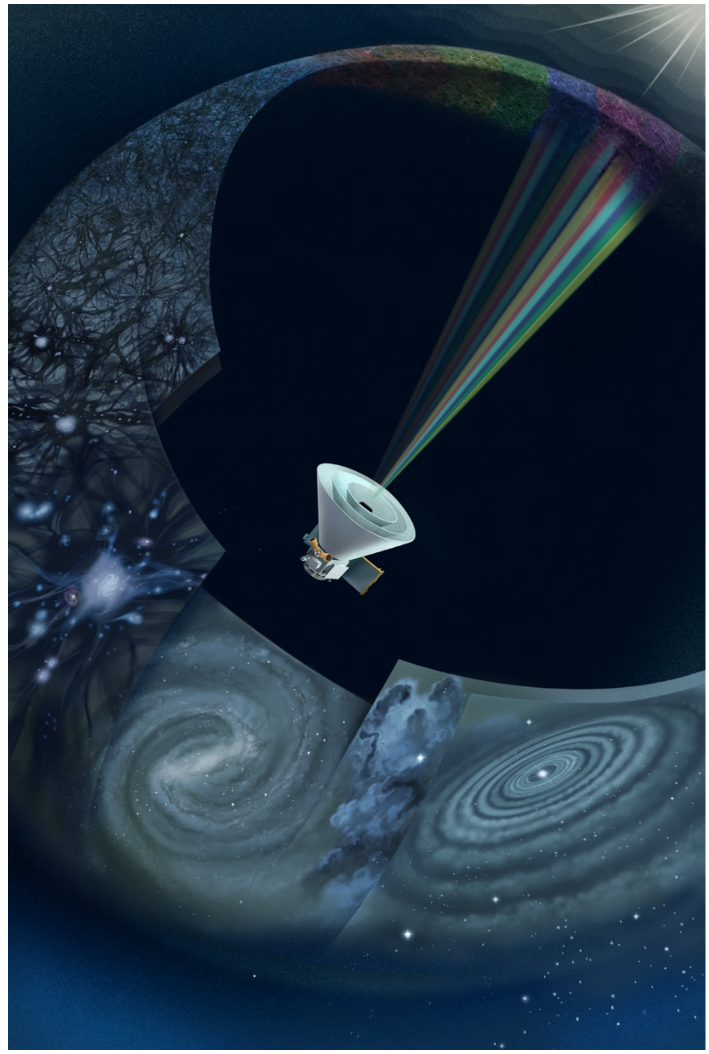
The mission's ability to scan the entire sky quickly and gather data on billions of stars and galaxies complements the work of more targeted telescopes, like NASA's Hubble and Webb space telescopes. While those telescopes can provide a more detailed look at a given target, survey telescopes like SPHEREx provide broader context and search for trends across entire categories of objects, including stars and galaxies.



SPHEREx, depicted second from right, joins a line of NASA space telescopes that includes, from left, Hubble, Spitzer, WISE, Webb, and Roman. Credit: NASA/JPL-Caltech | Full Image

3. This observatory will make the most colorful all-sky map ever.

It “sees” in the infrared range, which consists of wavelengths the human eye can’t detect. Using a technique called spectroscopy, the telescope splits light into 102 colors (individual wavelengths) like a prism creates a rainbow from sunlight. This enables it to detect evidence of chemical compounds and molecules, each of which has a unique signature in the colors it absorbs and emits. Spectroscopy can also help scientists measure how far away objects are, making it ideal for studying distant galaxies and mapping their locations in 3D.



Artist’s concept of SPHEREx. Credit: NASA/JPL-Caltech | Full Image

4. The mission will shed light on a cosmic phenomenon called inflation that took place less than a second after the big bang.

A simulation of the large-scale structure of the universe. Points of light are groups of galaxies. Credit: NASA/GSFC/AVL NCSA | Full Image

Less than one second after the big bang — the first billionth of a trillionth of a trillionth of a second, to be precise — space itself increased in size by a trillion-trillionfold. The SPHEREx mission will help scientists understand the physics that drove this nearly instantaneous event, called inflation. Small differences in the distribution of matter were amplified by inflation, influencing the large-scale structure of the universe today. The SPHEREx observatory will measure the distribution of hundreds of millions of galaxies to help scientists understand what drove inflation and to improve our understanding of the physics behind this extreme cosmic event.

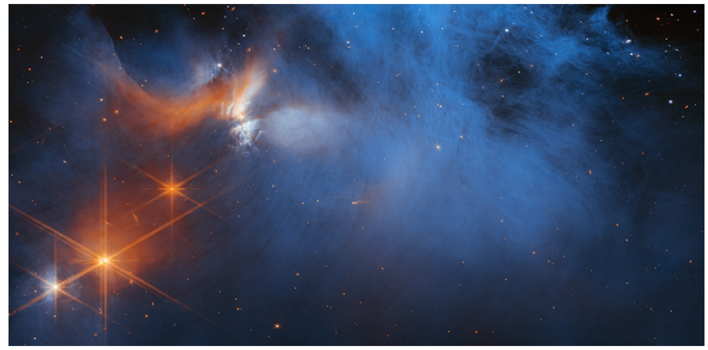
5. It will measure the collective glow from galaxies near and far, including hidden galaxies that have not been individually observed.

Scientists have tried to estimate the total light output from all galaxies throughout cosmic history by observing individual galaxies and extrapolating to the trillions of galaxies in the universe. The SPHEREx space telescope will measure the total glow from all galaxies, including galaxies that are too small or too distant for other telescopes to easily detect. This will give scientists a more complete picture of all the objects and sources radiating in the universe.

New tools yield new discoveries: The Hubble telescope peered into small patches of sky, revealing thousands of galaxies that our human eyes can't see. Using a different technique, SPHEREx will unveil the light of hidden galaxies on a universal scale. Credit: NASA/ESA/UC Santa Cruz/Leiden University/ HUDF09 | Full Image

6. The mission will search the Milky Way galaxy for essential building blocks of life.

Life as we know it wouldn't exist without basic ingredients such as water and carbon dioxide. The SPHEREx observatory is designed to find these molecules frozen in interstellar clouds where stars and planets form. The mission will help scientists discover the location and abundance of these icy compounds in our galaxy, giving them a better sense of how likely they are to be incorporated into newly forming planets.



Interstellar clouds such as Chamaeleon I, shown captured by NASA's Webb telescope here, can contain simple icy molecules that become incorporated in future planets. Credit: NASA/ESA/CSA | Full Image

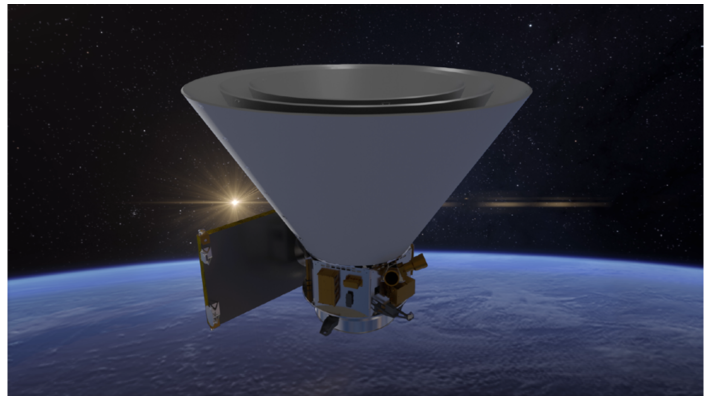
7. The observatory stays cold thanks to its unique cone-shaped design.

The mission's telescope and detectors need to operate around minus 350 degrees Fahrenheit (about minus 210 degrees Celsius); otherwise, they will generate their own infrared glow that might overwhelm the faint light from cosmic sources. SPHEREx relies on an entirely passive cooling system — no electricity or coolants are used, simplifying the spacecraft's design and operational needs. Key components of this system include three cone-shaped photon shields to protect the telescope from the heat of Earth and the Sun, as well as a mirrored structure beneath the shields to direct heat from the instrument out into space.

Artist's concept of SPHEREx showing its telescope within cone-shaped photon shields. Credit: NASA/JPL-Caltech | Full Image

8. The all-sky map generated by SPHEREx will be freely available to scientists around the world.

The mission will generate a new encyclopedia of information about hundreds of millions of celestial objects — including stars, galaxies, and even asteroids in our own solar system — most of which haven't been studied with spectroscopy before. Researchers will be able to access this mission's massive treasure trove of new cosmic data from anywhere on the globe.



Artist's concept of SPHEREx in Earth orbit. Credit: NASA/JPL-Caltech | Full Image

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Products and Events

News Releases, Features, Advisories, and Blogs

Progress reports on SPHEREx's road to launch, including the latest information on launch dates, can be found at blogs.nasa.gov/spherex.

News, updates, and feature stories about the SPHEREx mission are available at science.nasa.gov/mission/spherex.

Interviews with team members from the SPHEREx mission may be arranged by calling the JPL newsroom at **818-354-5011** or filling out this form.

Video and Images

B-roll and animations for media and public use are available at bit.ly/spherexvideo.

Embeddable SPHEREx videos are also available on JPL's YouTube channel.

Additional images related to the SPHEREx mission are available at the NASA Image and Video Library, Planetary Photojournal, and this press kit's Gallery section.

Read NASA's image use policy.

Read JPL's image use policy.

Media Events

A news conference presenting an overview of the mission will take place roughly 30 days ahead of launch.

A prelaunch news conference and a science news conference open to accredited news media will take place at Vandenberg Space Force Base (VSFB) in California in the days before launch. Additional briefings and media availabilities at VSFB are also expected in that time period.

All news briefings will be livestreamed.

How to Watch

Watch key coverage on NASA+. Learn how to watch NASA content through a variety of platforms, including social media at nasa.gov/general/watch-nasa-programming.

Programming will also be streamed live on the agency's website nasa.gov/live, YouTube.com/NASA, YouTube.com/NASAJPL, the NASA app, and NASA social media channels. (On-demand recordings will also be available on YouTube after live events have finished.)

For more information about NASA's live programming schedule, visit plus.nasa.gov/scheduled-events.

Live Launch Feed

A live video feed of key launch activities and commentary from mission control at VSFB will be broadcast. Media outlets interested in a "clean feed" of the launch without NASA TV commentary should contact nasa-dl-nasaplus-programming@mail.nasa.gov

Audio Only

Audio only of launch coverage will be carried on the NASA "V" circuits, which may be accessed by dialing **321-867-1220**, **-1240**, or **-7135**. On launch day, "mission audio" — the launch conductor's countdown activities without NASA TV launch commentary — will be carried on **321-867-7135**.

On-Site Media Logistics

Read NASA's media accreditation policy.

Media accreditation for on-site access closes for international media on Jan. 20, 2025, and for U.S.-based media (U.S. citizens and permanent residents) on Feb. 6. Accredited media will have access to VSFB for launch and pre-launch activities related to the SPHEREx mission. Closer to launch, NASA will release an events-and-briefings advisory with additional information.

Accredited news media can arrange on-site interviews by emailing Calla Cofield at calla.e.cofield@jpl.nasa.gov. Media without credentials can call the JPL newsroom at **818-354-5011** to see if off-site interviews can be arranged.

Additional Resources on the Web

Online and PDF versions of this press kit will be available at go.nasa.gov/spherexpresskit.

Find additional information about the SPHEREx mission at spherex.caltech.edu.

NASA's Eyes on the Solar System is a browser-based 3D simulation that allows users to visualize SPHEREx as it will appear in space. Explore this interactive experience at go.nasa.gov/eyesonspherex.

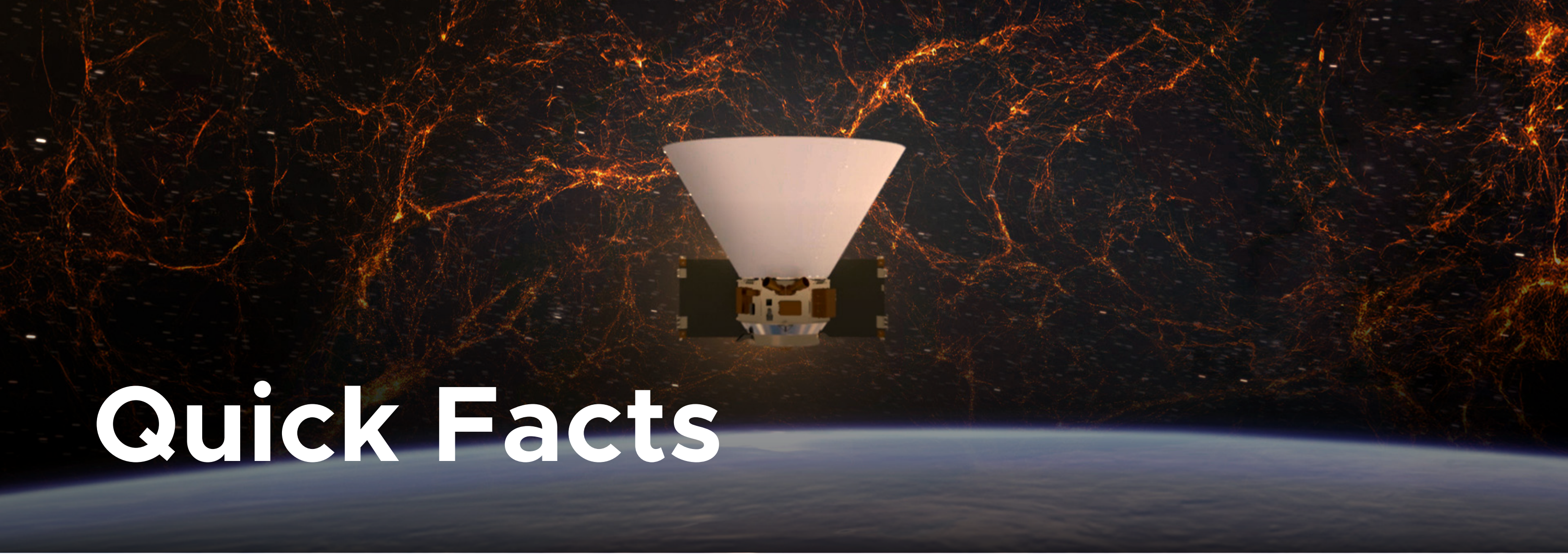
Social Media

Join the conversation and get updates from these accounts:

- **X:** @NASAJPL, @NASAUniverse, @NASA
- **Facebook:** NASAJPL, NASAUniverse, NASA
- **Instagram:** @NASAJPL, @NASAUniverse, @NASA

Launch day updates will also be available from:

- **X:** @NASA_LSP
- **Facebook:** NASALSP



Quick Facts

Mission

Name

Spectro-Photometer for the History of the Universe, Epoch of Reionization, and Ices Explorer (SPHEREx)

Duration

Prime mission of 27 months (including one month each for commissioning and decommissioning)

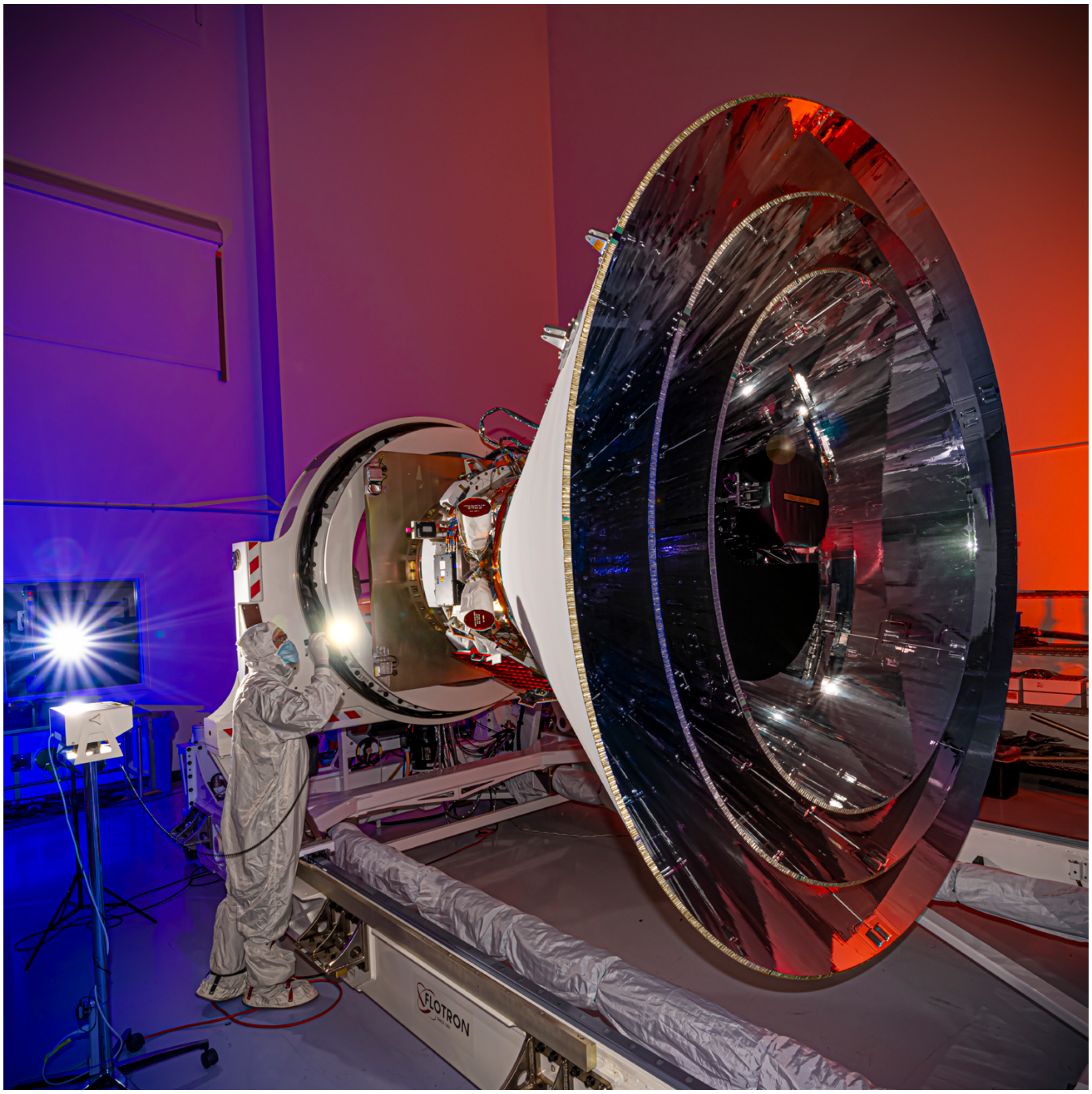
Orbit

Polar orbit around Earth at the day-night (terminator) line

Spacecraft

Dimensions

- **Overall dimensions:** 8.5 feet (2.6 meters) tall, 10.5 feet (3.2 meters) wide and deep
- **Solar panel:** 8.75 feet by 3.4 feet (2.67 meters by 1.02 meters); produces around 750 watts of power
- **Total weight/mass:** 1,107 pounds (502 kilograms)



A technician inspects the SPHEREx observatory during spacecraft testing at BAE Systems in Boulder, Colorado. Credit: NASA/JPL-Caltech/BAE Systems | Full Image

Telescope

The SPHEREx telescope has three mirrors, with an effective diameter of 7.9 inches (20 centimeters) and an 11-degree-by-3.5-degree field of view. It will take about 600 exposures of the sky each day and survey the entire sky about once every six months, completing four all-sky maps in its 27-month primary mission. The maps will be combined to increase resolution. The telescope relies on six linear variable filters to image each section of the sky in 102 wavelengths of near-infrared light.

Launch

Targeted Launch Date

No earlier than Feb. 27, 2025 (PST). See the mission blog for updates.

Targeted Launch Time

7:10 p.m. PST (10:10 p.m. EST), regardless of launch day

Launch Site

Space Launch Complex 4E, Vandenberg Space Force Base, California

Launch Vehicle

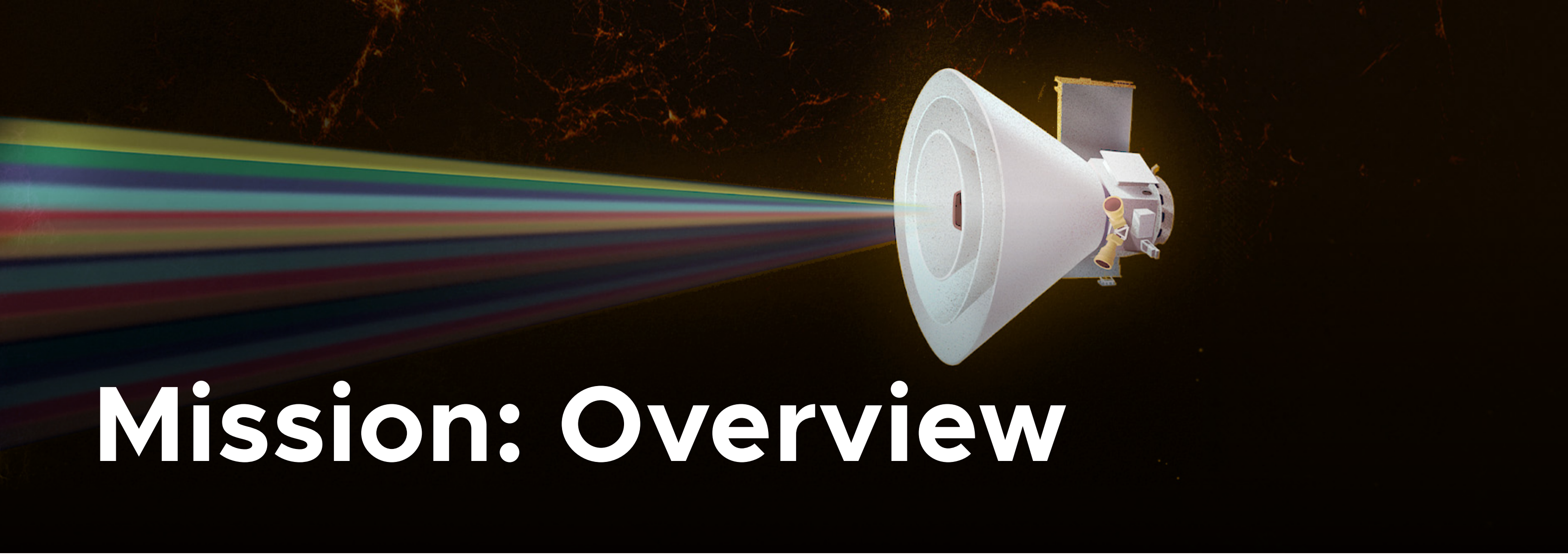
SpaceX Falcon 9 rocket

Launch Rideshare Partner

Launching as a secondary payload on the same Falcon 9 rocket will be NASA's PUNCH mission (Polarimeter to Unify the Corona and Heliosphere). Led by Southwest Research Institute's office in Boulder, Colorado, and managed by NASA's Goddard Space Flight Center in Greenbelt, Maryland, PUNCH is a constellation of four small satellites heading to low Earth orbit that will make global, 3D observations of the Sun's corona to learn how the mass and energy there become solar wind. For more information on PUNCH, visit science.nasa.gov/mission/punch.

Program

The total lifecycle cost to develop, launch, and operate SPHEREx under NASA's current budget planning is approximately $488 million.



Mission: Overview

NASA is targeting a launch for SPHEREx in late February 2025. Once in polar orbit around Earth, SPHEREx will begin a two-year mission to create the first all-sky spectroscopic survey in the near-infrared. Observing hundreds of millions of galaxies and a rich variety of astronomical phenomena, SPHEREx will investigate the origins of the universe, galaxies, and water and other life-sustaining molecules.

NASA's SPHEREx mission will lift off from Space Launch Complex 4E at Vandenberg Space Force Base in California aboard a SpaceX Falcon 9 rocket, just as the Surface Water and Ocean Topography mission, shown here, did in December 2022. Credit: NASA | Full Image

Launch

SPHEREx has its first launch opportunity Feb. 27, 2025, and is targeted to lift off no later than April 2025. Each day within the launch period provides a single, nearly instantaneous launch window around 7:10 p.m. PST (10:10 p.m. EST).

The mission will launch aboard a SpaceX Falcon 9 rocket, procured by NASA's Launch Services Program, from Space Launch Complex 4E at Vandenberg Space Force Base in California.

Launch Sequence

SpaceX's Falcon 9 is a two-stage rocket that will launch SPHEREx in a south-southwest direction over the Pacific Ocean.

Key events after launch (times approximate):

— 2 minutes and 14 seconds after liftoff: Main engine cutoff (MECO), second stage separation, and second-engine start 1 (SES1) will occur in quick succession. The reusable Falcon 9 first stage will then begin its automated return to the launch site for a powered landing.

— 3 minutes and 5 seconds: After protecting the satellite as the rocket traveled through the atmosphere, the launch vehicle's fairing, or nose cone, will separate into two halves and be jettisoned.

— 7 minutes and 9 seconds: Stage-II engine cutoff (SECO1) will take place, putting the launch vehicle and spacecraft in a coast phase.

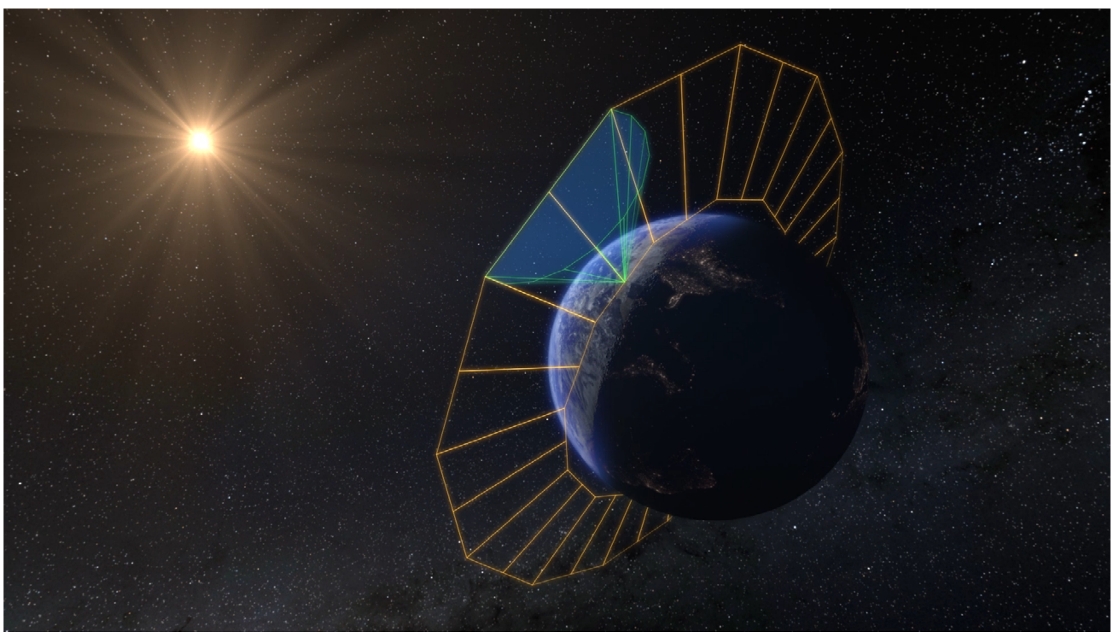
— 39 minutes: Stage-II first restart (SES2) will occur with a roughly 40-second burn, followed by stage-II engine cutoff (SECO2).

— 42 minutes: The launch vehicle and spacecraft will separate.

— 43 minutes: Initial acquisition of signal from the spacecraft is expected via the TrollSat ground station in Antarctica.

Orbit

The SPHEREx spacecraft will orbit Earth about 404 miles (650 kilometers) overhead. Its polar orbit is also Sun-synchronous, which means its orientation relative to the Sun remains consistent throughout the year. By remaining over Earth's day-night (or terminator) line for the entire mission, the observatory will keep the conical photon shields that surround its telescope pointed at least 91 degrees away from the Sun — an overwhelming source of light and heat. In addition, the telescope will point away from Earth and the bright infrared glow the planet produces. Each approximately 98-minute orbit allows the telescope to image a 360-degree strip of the celestial sky. As Earth's orbit around the Sun progresses, that strip slowly advances, enabling SPHEREx to complete an all-sky map within six months.



SPHEREx will look outward from low Earth orbit, circling the planet along its day-night (or terminator) line. This illustration depicts the spacecraft's orbital plane in orange, and its field of view in green. Credit: NASA/JPL-Caltech | Full Image

In-Orbit Checkout

Once SPHEREx is safely in orbit, controlling its orientation, and communicating with ground stations, the mission will transition to the in-orbit checkout phase. During this 30-day period, the mission team will complete the activities to prepare SPHEREx for its survey operations:

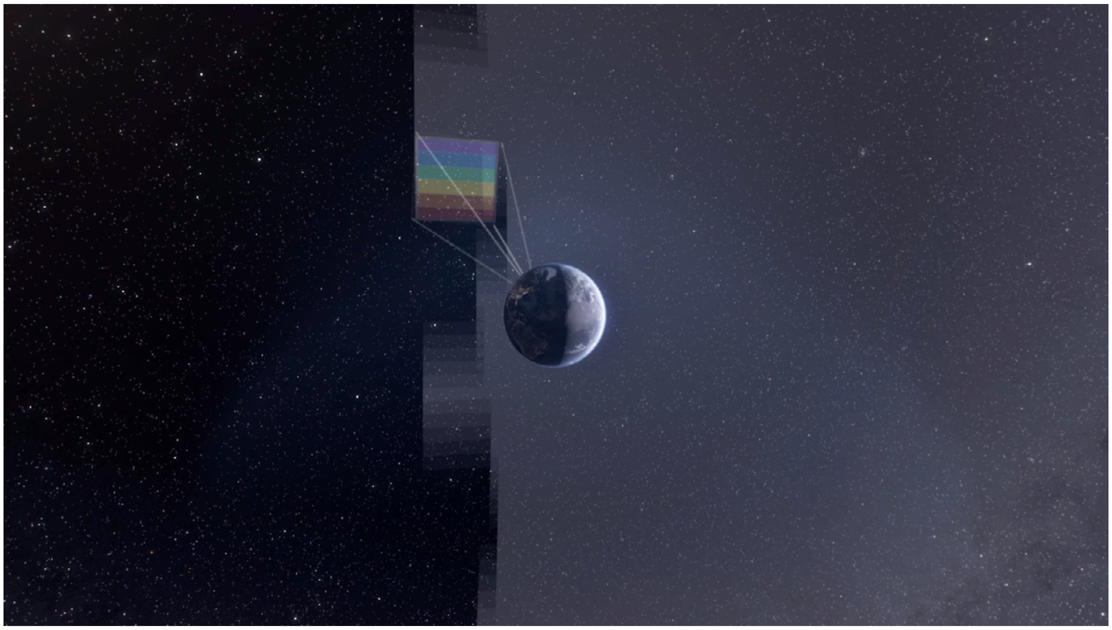
1. Commissioning the spacecraft, including all necessary calibrations
2. Cooling the telescope to its designed operating temperature
3. Characterizing the telescope's optical performance in space

Early in the commissioning phase, on the mission's third day, the spacecraft is scheduled to eject the dust cover latched in place over the telescope's primary instrument aperture. After the carefully orchestrated deployment — the mission's sole mechanical deployment — the cover will float away and eventually burn up in Earth's atmosphere.

The telescope will also begin cooling down passively to its desired operating temperature. Portions of the telescope, including some of its detectors, must be brought below minus 350 degrees Fahrenheit (about minus 210 degrees Celsius). (More information about cooling is available in the Spacecraft section.)

Survey Operations

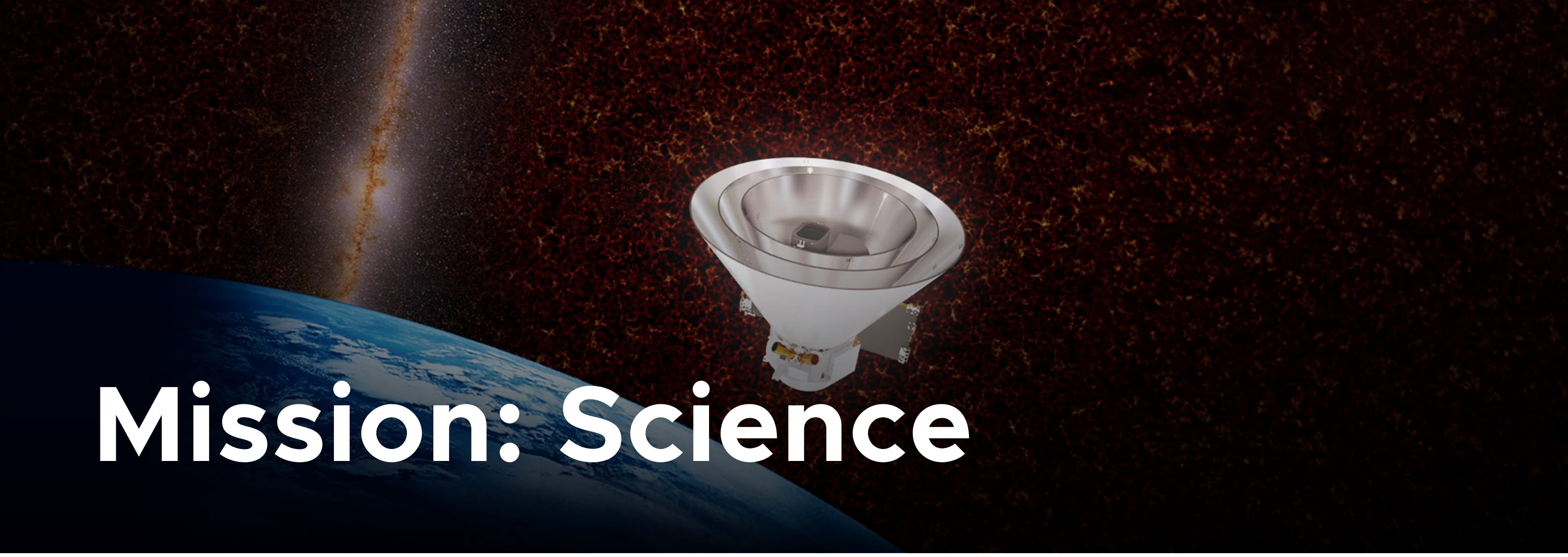
Once SPHEREx has been fully commissioned, the mission will begin its survey operations phase. Circling Earth about 14.5 times per day, SPHEREx will complete more than 11,000 orbits over its 25 months of planned survey operations. The spacecraft will take up to about 600 exposures per day, allowing it to complete four all-sky spectroscopic surveys during its prime mission.



SPHEREx All-Sky Survey (Animation) | bit.ly/3CdXvWG

Prime Mission Duration

The baseline mission for SPHEREx covers 27 months, including launch, one month of in-orbit checkout, 25 months of survey operations, and one month of decommissioning activities.



Mission: Science

Science Goals and Objectives

NASA's SPHEREx observatory will create a 3D map of the entire sky in 102 colors (each an individual wavelength of light) to help scientists answer big-picture questions about the origins of our universe, galaxies, and key ingredients for life in our galaxy, such as water. While this all-sky map can be used for a wide variety of science investigations, the SPHEREx mission will focus on three key science goals:

— Create a 3D map of hundreds of millions of galaxies in order to study inflation, which is the rapid expansion of the universe by a trillion-trillion-fold in less than a second after the big bang.

— Measure the total collective glow of galaxies near and far, including the light from sources that may be hidden or haven't yet been individually observed, such as faint or distant galaxies or populations of stars that have been pushed to peripheries of galaxies.

— Search the Milky Way galaxy for hidden reservoirs of water, carbon dioxide, and other essential ingredients for life, and measure their abundance and availability for newly forming planets.

Science Technique

SPHEREx will achieve these goals using a technique called spectroscopy, which splits light into different wavelengths, like a prism creates a rainbow from sunlight.

What human eyes perceive as colors are actually different wavelengths of light. The wavelengths that SPHEREx can detect — in the infrared range — are slightly longer than what human eyes can see. When astronomers image a cosmic object, they see all the wavelengths emitted by that object mixed together. Through spectroscopy, SPHEREx can separate the colors to reveal the composition of objects; that's possible because chemical elements and molecules leave a unique signature in the colors they absorb and emit. Spectroscopy can also help scientists measure how far away objects are, making it ideal for studying distant galaxies and mapping their locations in 3D.

The observatory will sweep across the sky, taking about 600 exposures each day that can be combined to create an all-sky mosaic. Every section of the sky will be imaged 102 times, each time using a different color filter that blocks all wavelengths except one. Combining those images, scientists can see the total emission from that section of the sky or look at an individual wavelength.

Spectroscopy explained: Take a deeper dive to learn about this technique and how scientists use it. (Video) | bit.ly/3BFKHZp

Wavelength Range

The SPHEREx telescope will collect light in the infrared range, which includes some of the predominant wavelengths emitted by stars and galaxies, making it ideal for SPHEREx's study of the collective galactic glow. Infrared is also useful for studying distant galaxies, whose visible light is stretched by the universe's expansion, shifting it into the infrared range. A third advantage of operating in the infrared: The spectroscopic chemical signatures for water, carbon dioxide, and carbon monoxide are in that range.

Survey Telescopes vs. Targeted Telescopes

Generally speaking, most space telescopes are either survey telescopes or targeted telescopes. As a survey telescope, SPHEREx is designed to study large portions of the sky relatively quickly. Other survey telescopes include the first infrared space telescope, NASA's IRAS mission (short for Infrared All-Sky Survey), which launched in 1983. Many others have followed, including NASA's WISE (Wide-Field Infrared Survey Explorer) launched in 2009, the agency's upcoming Nancy Grace Roman Space Telescope, which is scheduled to launch by 2027, and the ESA (European Space Agency) Euclid telescope, which launched in 2023.

Targeted telescopes typically have narrower fields of view but higher resolution compared to survey telescopes and are capable of observing fewer objects in much better detail. NASA's Webb and Hubble space telescopes are prime examples.

Scientists use both types of telescopes to understand the universe. Survey missions, for example, can scan large sections of the sky and identify objects of interest for targeted telescopes to study in more detail. Targeted telescopes can provide intricate details about how individual objects like stars and black holes affect their surroundings, while survey telescopes can provide information about the average properties of these objects on a population level.

Science Goals in Detail

Many space telescopes look closely at cosmic objects to provide insights into the cosmos, but trying to answer some questions about the universe requires a wider view. Here's what scientists expect to learn from SPHEREx's spectroscopic all-sky map.

Origins of the Universe

The mission will map the position of hundreds of millions of galaxies in 3D to study the physics of inflation, the event that caused the universe to expand by a trillion-trillionfold in less than a second after the big bang. Because this event subtly influenced the distribution of matter in the universe, taking a precise look at the distribution of galaxies today enables scientists to investigate the turbulent beginnings of the universe nearly 14 billion years ago.

No other known event or process in the universe involves the amount of energy required to drive inflation; studying it presents a unique opportunity to understand more deeply how our universe works. By mapping the positions of so many galaxies and measuring the average distribution of matter across the universe, SPHEREx will help dramatically narrow down the number of theoretical models of inflation.

Origins of the Galactic Glow

By measuring the collective glow created by all galaxies near and far, SPHEREx will calculate the total amount of light emitted by galaxies over cosmic history. Scientists have tried to estimate this total light output by observing individual galaxies and extrapolating to the trillions of galaxies in the universe. But such counts may leave out some faint or hidden sources of light — galaxies that are too small or too distant for telescopes to easily detect, for instance, or stars at the periphery of galaxies, which may have been pushed there when two galaxies merged. SPHEREx will give scientists a more complete picture of all the objects and sources of light in the universe.

Because light takes time to travel through space, we see distant objects as they were in the past: Astronomers looking at objects billions of light-years away are seeing those objects as they were billions of years ago.

Spectroscopy enables scientists to discern how far light has traveled to reach us and when in the universe's history it was released. Using the technique, SPHEREx can also show astronomers how this total galactic light output has changed over time. For example, the telescope may reveal that the first generation of galaxies in the universe produced more light than previously thought, either because there were more of them or because they were bigger and brighter than current estimates suggest.

Having a better estimate of the total number of galaxies at different epochs in the universe's history can improve computer models and simulations of how galaxies form and evolve.

Origins of Water in the Milky Way

How do planets form and where do water and other ingredients for life as we know it come from? SPHEREx will make more than 9 million observations of the Milky Way galaxy to search for hidden reservoirs of water, carbon dioxide, and other molecules in the space between stars. In this largely empty space, gas and dust can cluster together in molecular clouds, which are dense regions where stars and planets eventually form. These clouds likely contain the raw materials that could form rocky worlds with large oceans, like Earth.

Previous attempts to look for these materials in molecular clouds in the form of gas have found less of them than scientists expected. Further analysis and observations suggest that significant amounts of water and other molecules likely exist not as gas but in the form of ice attached to small dust grains, which can eventually become part of newly forming planets.

Spectroscopy can be used to identify water ice and other frozen elements because these molecules leave a specific chemical fingerprint in the wavelengths of light they absorb and emit — wavelengths that SPHEREx can detect.

Targeted observatories have detected these ices in our galaxy. As a survey telescope, SPHEREx will make millions of measurements, providing a comprehensive view of the abundance and distribution of these molecules throughout the galaxy. Targeted telescopes could then follow up on these observations and obtain more detailed views of individual molecular clouds or even newly forming star and planet systems.

Mission: Spacecraft

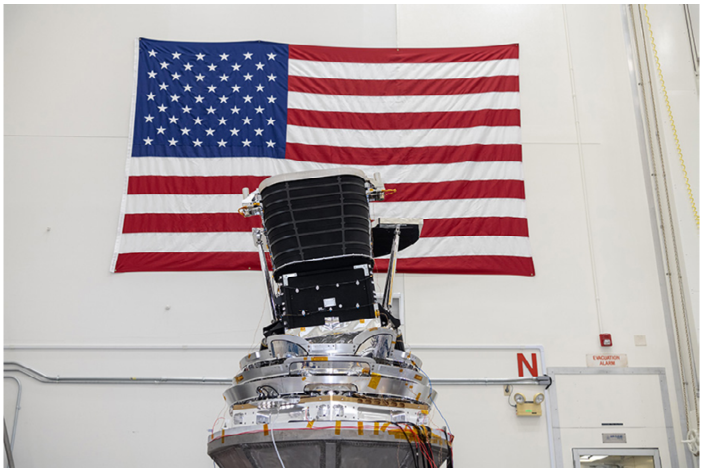
SPHEREx Observatory

The SPHEREx observatory is built to survey the entire sky in infrared light. Standing 8.5 feet (2.6 meters) tall, its most prominent feature is a set of cone-shaped photon shields that measures 5.6 feet (1.7 meters) tall and 10.5 feet (3.2 meters) in diameter. The three concentric shields surround the telescope, which uses three mirrors to collect light from cosmic sources and feed it to the detectors. The shields protect this hardware from light and heat from the Sun and Earth. The cones, telescope, and detectors sit atop a trio of structures called v-groove radiators. Each radiator consists of three conical mirrors that resemble an upside-down umbrella and are stacked atop one another. Composed of a series of wedges that redirect infrared light so it bounces through the gaps between the photon shields and out into space, they help to keep the telescope cool.

The assembled SPHEREx observatory (including its outer photon shield but excluding its solar panel) stands on one end in the BAE Systems spacecraft assembly facility in Boulder, Colorado. Credit: NASA/JPL-Caltech/BAE Systems | Full Image

Underneath the photon shields and v-groove radiators is the part of the observatory known as the spacecraft bus. It includes the main computer, solar panel, and equipment for communicating with Earth and controlling the spacecraft's orientation.

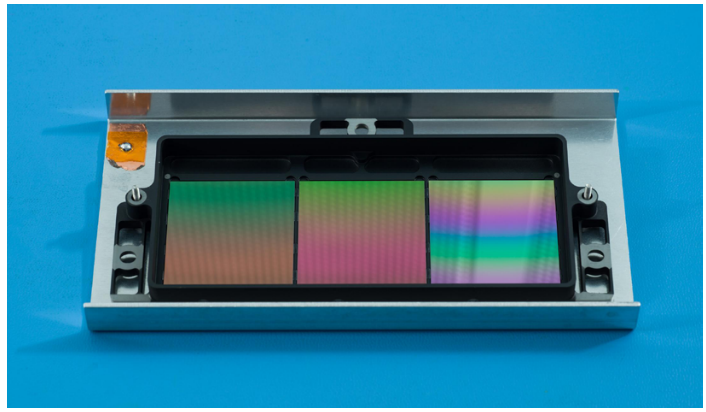
Telescope and Detectors



The telescope for NASA's SPHEREx mission undergoes testing at NASA's Jet Propulsion Laboratory in Southern California. Credit: NASA/JPL-Caltech | Full Image

The heart of SPHEREx is its telescope, which collects infrared light from distant sources using three mirrors. The primary mirror has an effective diameter of 7.9 inches (20 centimeters) and an 11.3-degree by 3.5-degree field of view. Its images will each contain over 24 million pixels.

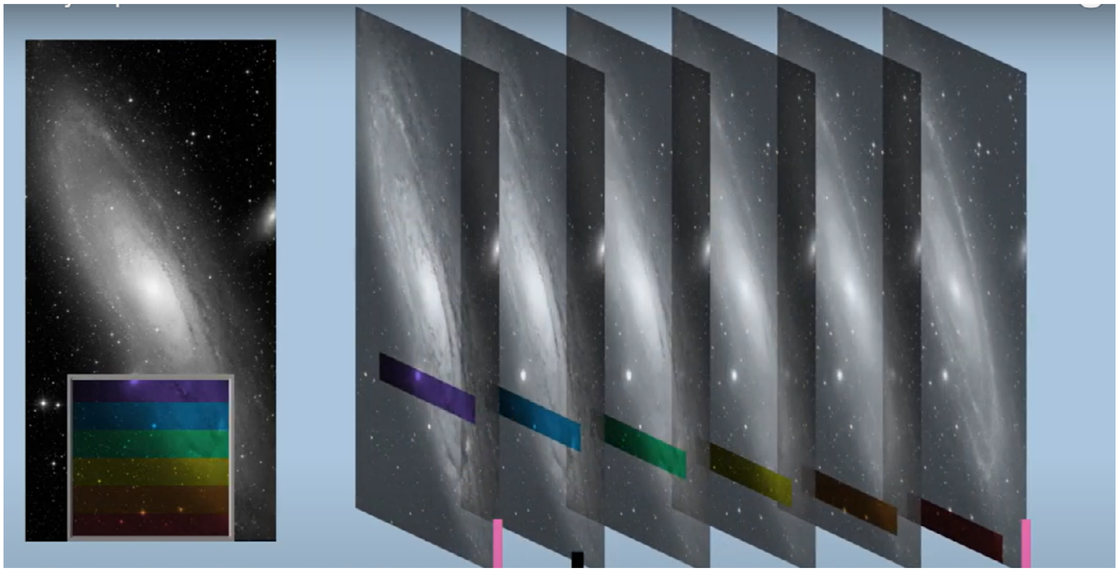
The light from the telescope is split into two beams that are directed to sets of detectors and filters, collectively called the focal plane arrays. The observatory features six detector arrays, each 1.6 inches (41 millimeters) square and containing 4.2 million pixels. On top of the detectors are color filters that enable SPHEREx to conduct spectroscopy, separating light from a source into its component wavelengths.



Three of the filters on SPHEREx's detectors that will allow it to image the sky in 102 separate infrared colors (distinct wavelengths). Credit: NASA/JPL-Caltech | Full Image

Most astrophysics telescopes that do spectroscopy use detectors that collect light from one source at a time. With its unique design, SPHEREx will conduct spectroscopy on hundreds of thousands of objects simultaneously. Combined with the telescope's wide field of view, this capability will enable SPHEREx to complete a spectroscopic map of the entire sky every six months.

SPHEREx has only six filters, but they detect 102 wavelengths of infrared light in total. Each filter has 17 color bands, distinct regions that look like stripes. The wavelengths vary continuously over the filter in a gradient, similar to the gradual transition between the colors of a rainbow. Each point of the sky is observed in one of the 17 color bands at a time. A similar approach is used in planetary science to conduct spectroscopy up close across the surface of planets or moons.



The SPHEREx survey, explained (Video) | bit.ly/4f8vgHl

Pointing

For the SPHEREx telescope to complete its overlapping images of each section of the sky, the entire observatory shifts position — the mirrors and detectors don't move as they do on other telescopes. And rather than using thrusters or chemical propellant to alter the direction it is pointing, the spacecraft relies on a system of gyroscopes, reaction wheels, and magnetic torque rods.

Cooling System

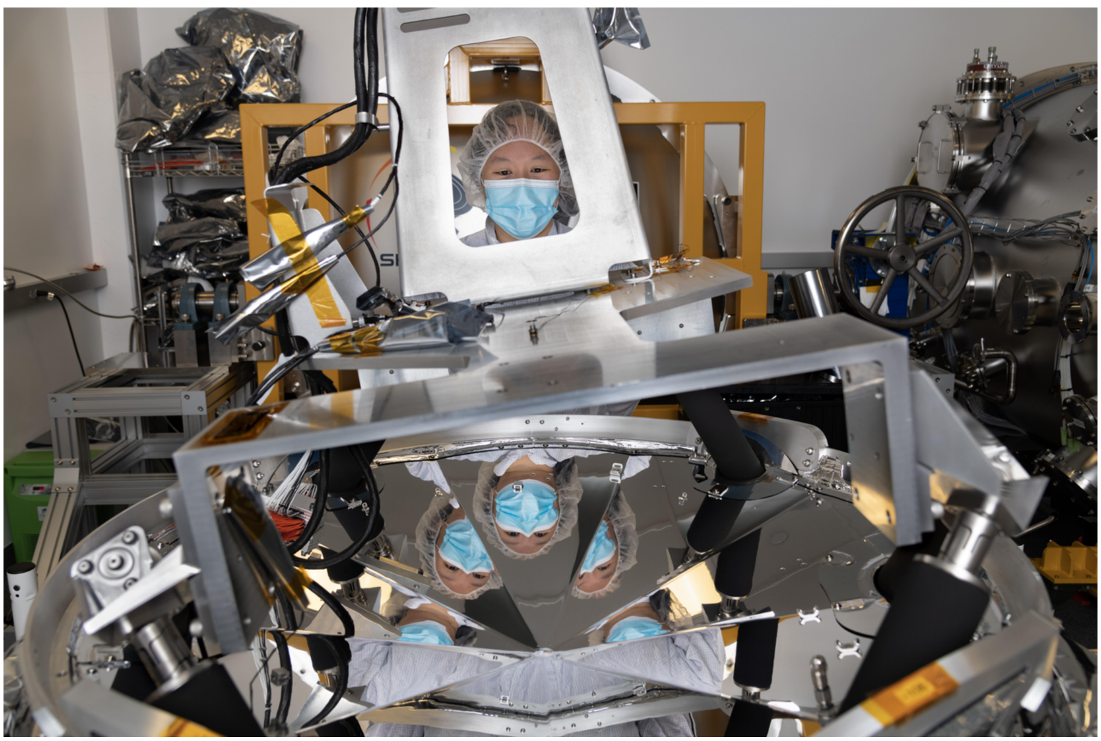
The SPHEREx telescope and detectors must be cooled down once the observatory reaches its orbit. The detectors need to be kept around minus 350 degrees Fahrenheit (about minus 210 degrees Celsius). Otherwise, SPHEREx will generate an infrared glow that might overwhelm the faint light from cosmic sources. For comparison, temperatures in Antarctica dip as low as minus 120 F (minus 85 C), while parts of the surface of the Moon at night reach minus 280 F (minus 173 C).

The spacecraft's innovative design enables the cooling system to be entirely passive, requiring no electricity or coolant during normal operations, simplifying operational needs. Before the observatory begins normal operations, a set of electric decontamination heaters will be used for a few days to reduce the risk of ice forming on critical components during the initial instrument cooldown.

Cooling Structures

Two key structures contribute to the passive cooling system: the set of three cone-shaped photon shields and the v-groove radiators.

The photon shields, each about 0.75 inches (19 millimeters) thick, surround the telescope and block light from the Sun and Earth from entering or warming it. Constructed with a geometry similar to cardboard, the cones feature two thin aluminum sheets separated by aluminum shaped like a honeycomb. The reflective aluminum surfaces bounce light and heat out into space, and the exterior of the outer cone is painted white to reflect sunlight and radiate heat.



One of three SPHEREx v-groove radiators — a series of mirrored wedges that redirect infrared light so it bounces out into space — is shown at the bottom of this image. Two additional v-groove radiators sit below this one, each slightly wider than the one on top of it, so they can bounce light up through the gaps between the three photon shields. Credit: NASA/JPL-Caltech | Full Image

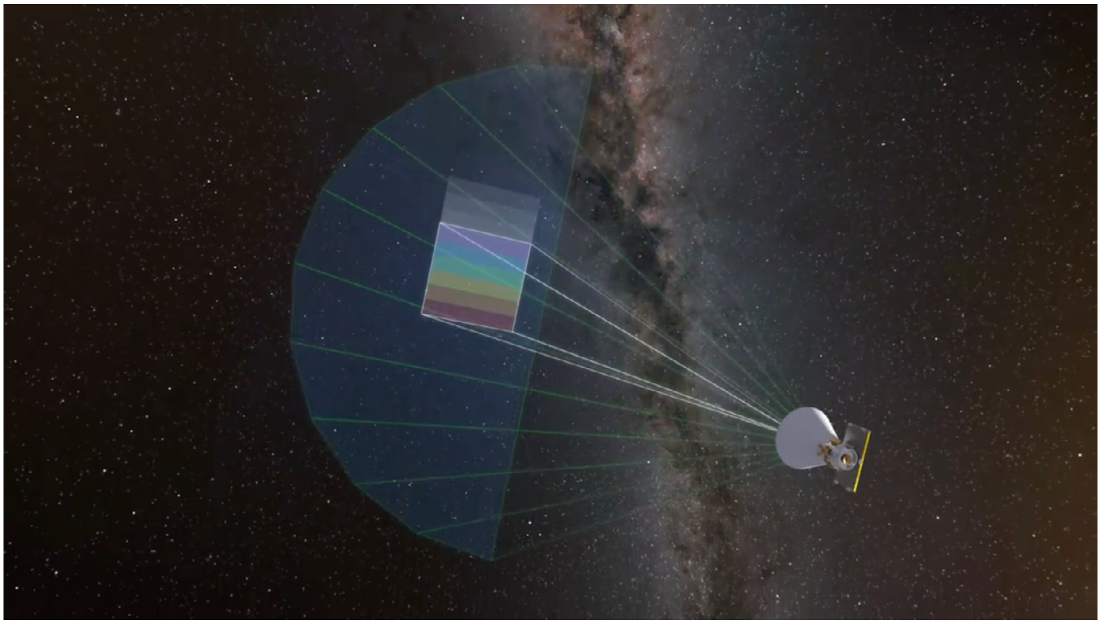
The telescope sits on three structures called v-groove radiators, which have reflective surfaces that bounce light and heat away from the telescope out into space.

The struts that connect the telescope to the rest of the spacecraft are designed to reduce heat transfer.

Cooling Orbit and Orientation

The orbit of SPHEREx and its orientation relative to the Sun and Earth will also help keep the telescope cool. Both the Sun and Earth radiate light that can warm SPHEREx's hardware or overwhelm its detectors, making it difficult or impossible for them to collect light from faint cosmic sources. During survey operations the telescope will therefore always be pointed fully away from Earth, looking out into space.

Because staying pointed away from the Sun is more challenging, SPHEREx will orbit from north to south over Earth's poles along the terminator line, which separates day and night on a celestial object. From this orientation, the opening at the top of the photon shields will continuously point at least 91 degrees away from the Sun. Inside the protective shields, the telescope is slightly tipped toward the Sun so that the full sky can be observed.



SPHEREx Orbit (Animation) | bit.ly/3UE5KS8

Flying at the terminator line also means SPHEREx will be exposed to similar amounts of light and darkness during each orbit, which will keep the spacecraft's temperature more stable than if its orbit passed through varying light levels.

Power

SPHEREx is powered by a single fixed solar panel that measures 8.75 feet by 3.4 feet (2.67 meters by 1.02 meters) and produces roughly 750 watts of power. The observatory's orbit along Earth's terminator line means its solar panel will almost always face the Sun and the power it generates won't vary significantly in a given orbit. A battery aboard the spacecraft will provide power before SPHEREx reaches orbit and during brief periods when it falls into Earth's shadow.

Communications and Data

SPHEREx will communicate with Earth via five microwave antennas: three S-band and two Ka-band. Two S-band antennas are located on either end of the solar panel and will be used to send telemetry (data on the health and status of the spacecraft). A higher-gain S-band antenna sits on the bottom of the spacecraft bus and will be used to receive commands. Also located on the bottom of the spacecraft are the Ka-band antennas that will send science data to Earth. These have a higher data rate than the S-band antennas; however, they are cone-shaped, while the S-band antennas are omnidirectional, so the S-band antennas can communicate with ground stations for longer periods.

Because SPHEREx has a 98-minute polar orbit at Earth's day-night line, it will most frequently fly over areas close to the poles. To take advantage of this, the spacecraft will communicate via ground stations in Troll, Antarctica; Fairbanks, Alaska; Punta Arenas, Chile; and Svalbard, Norway. The ground stations are part of NASA's Near Space Network, which is managed and operated by NASA's Goddard Space Flight Center in Greenbelt, Maryland. During each ground station pass, the S-band can transmit data for about 10 minutes and the Ka-band can transmit for about three minutes. An average of five passes will occur per day.

Near Space Network antennas at the Alaska Satellite Facility in Fairbanks, Alaska. Credit: NASA | Full Image

The observatory will take about 600 science exposures per day. Because there are six detectors, this produces about 3,600 individual images. The onboard software will take a series of steps to reduce the amount of data that needs to be sent down to Earth by a factor of about 175. This includes a compression algorithm and an algorithm that estimates the flux in each pixel and reduces it to a single value per pixel, instead of the roughly 70 values per pixel that are initially produced by the detectors.

Ground Systems

Satellite Operations

The observatory will be operated from the Earth Orbiting Mission Operations Center at NASA's Jet Propulsion Laboratory in Southern California. Spacecraft support will be provided by BAE Systems in Boulder, Colorado. Payload instrument support will be provided by Caltech. Survey planning support will be provided by Arizona State University in Tempe.

Science Data Processing

The SPHEREx Science Data Center at Caltech's IPAC will perform scientific data processing and analysis. Data releases to the science user community and archiving will be carried out through the NASA/IPAC Infrared Science Archive (IRSA).

Management

The SPHEREx mission is sponsored by NASA's Science Mission Directorate in Washington, where **Nicola Fox** is the associate administrator and **Eric Smith** is the acting director of the Astrophysics Division. **Mark Sistilli** is the SPHEREx program executive and **John Wisniewski** is the program scientist.

SPHEREx is a Medium Explorer Mission. The Explorers program is managed by NASA's Goddard Space Flight Center in Greenbelt, Maryland.

NASA's Jet Propulsion Laboratory, a division of Caltech in Pasadena, California, is responsible for the mission's overall management and operations. At JPL, **James Fanson** is the SPHEREx project manager, **Beth Fabinsky** is the deputy project manager, and **Olivier Doré** is the project scientist. The mission principal investigator, **Jamie Bock**, is based at Caltech with a joint appointment at JPL.

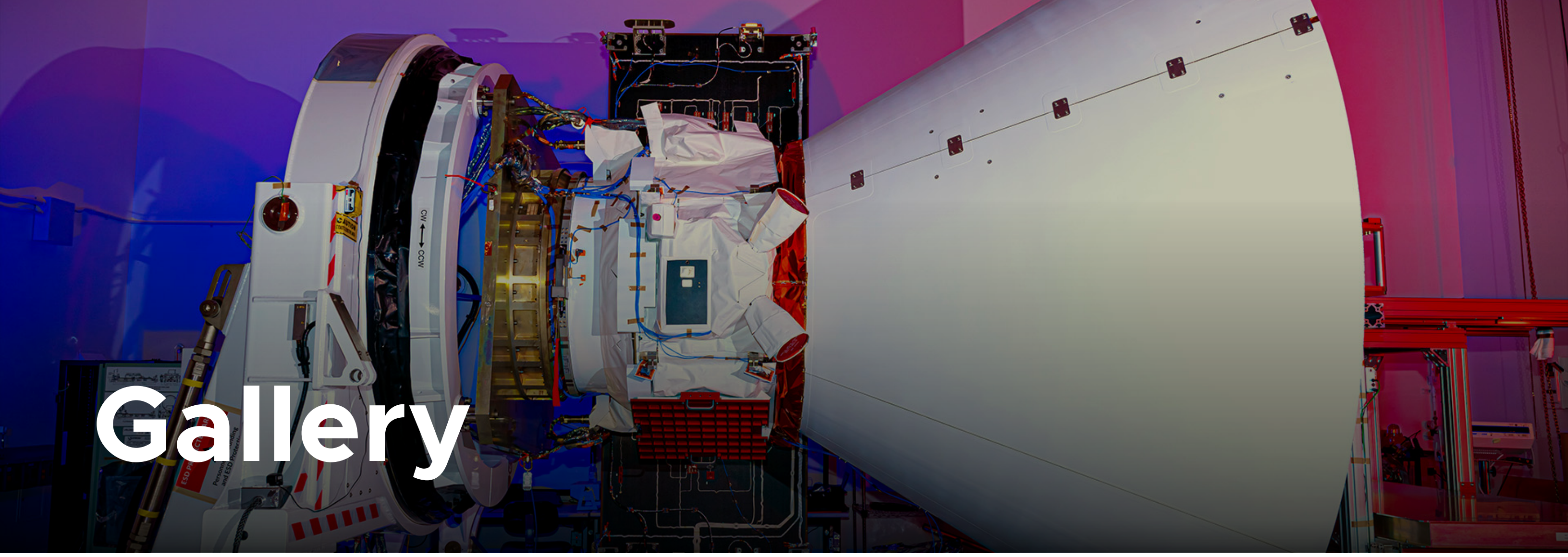
BAE Systems (formerly Ball Aerospace) in Boulder, Colorado, built the telescope and the spacecraft bus and is responsible for integration and testing.

The science analysis of the SPHEREx data will be conducted by a team of scientists located at 10 institutions in the U.S., two in South Korea, and one in Taiwan: Caltech, the Center for Astrophysics | Harvard & Smithsonian, Arizona State University, the University of California Irvine, the University of Arizona, the Rochester Institute of Technology, Argonne National Laboratory, the Ohio State University, the Johns Hopkins University Applied Physics Laboratory, KASI (Korea Astronomy and Space Science Institute) and Seoul National University, and the Academia Sinica Institute of Astronomy & Astrophysics (ASIAA) in Taiwan.

KASI built and delivered a specialized test chamber for the SPHEREx detectors and optics.

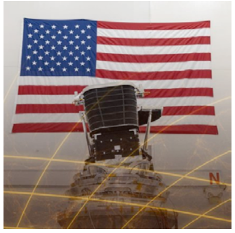
Data will be processed and archived at IPAC at Caltech.

NASA's Launch Services Program (LSP), based at the agency's Kennedy Space Center in Florida, is responsible for management of the launch service. **Denton Gibson** is the LSP launch director/manager. **Serkan Bastug** is the LSP mission manager. **Maxx Taga** is the launch site integration manager for SPHEREx.



Gallery

Images



NASA Image and Video Library

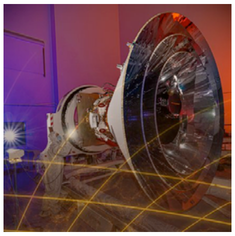
SPHEREx images and videos from a NASA-wide library

go.nasa.gov/4efck9C

Planetary Photojournal

SPHEREx images from the planetary image library managed by NASA's Jet Propulsion Laboratory

go.nasa.gov/4dloZGO

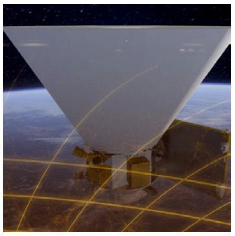


SPHEREx Gallery at Caltech

Spacecraft images from the SPHEREx website at Caltech

spherex.caltech.edu/images

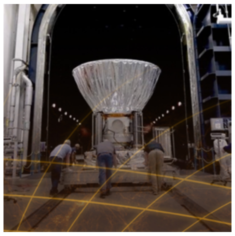
Web Videos



Mission Overview

Short video explainer about the SPHEREx mission featuring interviews, animation, and behind-the-scenes footage

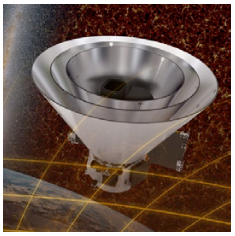
bit.ly/spherexoverview



Spacecraft Makers: SPHEREx

Behind-the-scenes video focusing on the testing the space telescope

bit.ly/spherexmakers

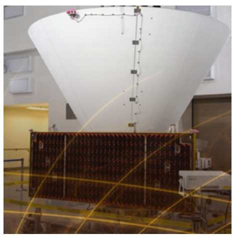


SPHEREx Video Playlist

Comprehensive list of JPL videos highlighting the SPHEREx mission

bit.ly/spherexplaylist

Animations and Raw Videos

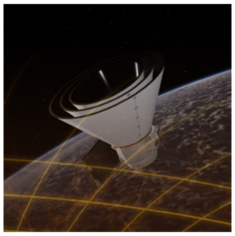


Collection of Animations and B-Roll for Media

Mission animations; b-roll of spacecraft assembly, testing, and shipping

bit.ly/spherexvideo

Interactive Experience



NASA Eyes on the Solar System

Browser-based 3D simulation showing SPHEREx in the orbit from which it will make its observations

go.nasa.gov/eyesonspherex