Behind the Scenes of the Big Bang

The Caltech-led NASA **SPHEREx** mission will provide new clues about the explosive, inflationary phase of our universe.

By Whitney Clavin

NASA's newest astrophysics observatory, SPHEREx, is on its way to help humanity understand how our universe came into existence. Short for Spectro-Photometer for the History of the Universe, Epoch of Reionization and Ices Explorer, SPHEREx lifted off on March 11, 2025, aboard a SpaceX Falcon 9 rocket from Vandenberg Space Force Base in California.

SPHEREx is led by principal investigator Jamie Bock, the Marvin L. Goldberger Professor of Physics at Caltech and a senior research scientist at NASA's Jet Propulsion Laboratory (JPL), which is managed by Caltech. Several groups worked together to develop the observatory, including researchers from Caltech's campus, IPAC, and JPL, which is managing the mission.

SPHEREx's three primary goals are to explore the origins of water and organic molecules in regions where stars form, the history of galaxy formation, and the mechanisms behind cosmic inflation—the "bang" in the big bang that set our universe in motion. The mission will map the sky four times over a period of two years, using infrared light to capture detailed spectral information for every point, or pixel, on the sky, including hundreds of millions of galaxies.

SPHEREx will provide new clues in the quest to understand cosmic inflation, a much-studied theory that states our newborn universe expanded a trillion-trillion-fold in a fraction of a second—much less time than it takes to snap your fingers. After that initial blast, the universe continued to expand, albeit at a more leisurely pace.

The 3D map will allow scientists to study the distribution, or clumpiness, of galaxies—a trait that subtly differs from one model of inflation to the next. Because the imprints of inflation will be the strongest on the largest scales, the best information on inflation comes from mapping a large volume of the cosmos.

"I can't think of a more profound question: studying the first fractions of a second of existence," says Phillip Korngut, the mission's instrument scientist at Caltech. "The clumpiness in galaxy positions is tied to quantum fluctuations in the early universe when it was unfathomably tiny and hot. We are making precise measurements of galaxy density variations and then will tie that back mathematically to what happened in the early universe."

To capture such a gigantic 3D sky map, SPHEREx makes a trade-off between the numbers of galaxies it can observe and the accuracy of their measured distances. The galaxies' distances are determined through a phenomenon known as redshift, which occurs when light from the galaxies is shifted to longer wavelengths due to the expansion of the universe.

"One of the innovations for SPHEREx is low-resolution spectroscopy, which we use to get large numbers of redshifts," Bock says. "On the one hand, you can't see many spectral lines, but you can see more of the sky faster with lower-resolution spectroscopy. We will see hundreds of millions of galaxy redshifts with low accuracy, and tens of millions with high accuracy."

Korngut explains that SPHEREx is essentially doing the opposite of what NASA's James Webb Space Telescope (JWST) does so well. "JWST can go really deep on little chunks of sky and explore galaxies in detail," he says. "For us, galaxies are just points in space."

IPAC, a science and data center for astronomy at Caltech, will both process mission data that streams in from space and serve as the main public data archive. "Caltech has been the perfect place for a mission of this scale due to the close connections between Caltech, JPL, and IPAC," Bock says. "What makes this partnership work is a 'badge-less environment,' where our relatively small team interacts closely on a daily basis without barriers. It is essential that many personal connections were already well established across the team before the project began. Caltech undergrads, graduate students, postdocs, and staff have had significant impacts in all phases of the project."

SPHEREx team members can be seen above in a reflection from the chamber's gold-coated, sapphire window. The window protects the telescope inside the chamber from the infrared glow of the lab outside. Clockwise from top are Stephen Padin, Phil Korngut, Chi Nguyen (taking the photo), and Howard Hui.

Read more about SPHEREx