

Boulder creation could help unveil ancient universe

Spectrograph is a key scientific justification of Hubble mission

By Todd Neff

Camera Staff Writer

NASA's announcement last week that it would repair and upgrade the famed Hubble Space Telescope means that a Boulder creation with breathtaking scientific potential will finally take flight in 2008.

The \$40 million Cosmic Origins Spectrograph, designed at the University of Colorado and built at Boulder's Ball Aerospace, has the potential to help scientists untangle the cosmic web, unveiling some of the universe's best-kept secrets. Many astronomers see its installation as a key scientific justification for the fifth and final space shuttle visit to Hubble, whose life will be extended until 2013 or longer.

Hubble's gorgeous photos are computer-desktop mainstays. But the barcode lines of ultraviolet spectra delivered by the Cosmic Origins Spectrograph could help astronomers connect the dots between the ancient and modern universes and confirm the structure of creation.

"We have this piñata, and we know there's some interesting astronomy in there, but only a few little pieces have fallen out," said Todd Tripp, a University of Massachusetts Amherst astronomer. "COS is the stick that's going to be able to open that piñata and release a flood of data."

Hubble's existing Advanced Camera for Surveys and the new Ball Aerospace-built Wide Field Camera 3, also awaiting a 2008 shuttle ride, are fine instruments, Tripp said.

"But COS is the one that really provides the brand-new capability," he said. "This new spectrograph, I think, is going to really open up the floodgates."

The science

The Cosmic Origins Spectrograph is designed to observe ultraviolet light. Such light has shorter wavelengths than the human eye can detect, and Earth's atmosphere largely absorbs it before it can reach telescopes on the ground.

Atoms and molecules absorb, and stars and quasars pour out, huge amounts of ultraviolet radiation, said University of Colorado astrophysicist and COS science-team member Michael Shull.

"So if you want to study quantitatively where stuff is — matter, metals, heavy elements and other molecules — you want to go to the ultraviolet," Shull said.

If the universe were a library, the classics would be written in the infrared.

As the cosmos expanded after the big bang 13.7 billion years ago, its earliest ultraviolet light was stretched and progressively reddened. Infrared telescopes such as the Spitzer Space Telescope and the James Webb Space Telescope, which is now being built at Ball Aerospace & Technologies Corp. in Boulder, are designed to read the cosmic equivalent of cave paintings.

But such "redshift" has yet to happen with the universe's modern stories — told by stars and galaxies merely a few billion years old. Some of their light is visible, and hence all the Hubble-image screen savers. But to really understand it all, one needs a way to read its native ultraviolet splendor.

The atmosphere absorbs UV for a reason — atoms and molecules in the air soak up its energy. This turns out to be a widespread habit. Great clouds of gas wafting amid stars and galaxies do the same thing.

A device capable of sensing ultraviolet light through such gases can tease out information on the star, quasar or galaxy as

well as the nature of the cloud itself.

Shull says clouds in the so-called intergalactic medium probably contain up to 90 percent of the universe's periodic matter, some 60 percent of which remains unaccounted for. Galaxies condense out of them and eventually blast material back into them as dying stars explode. Theorists say it's all strung together in a three-dimensional web, and limited observations from previous ultraviolet instruments seem to verify it.

Connecting the dots

University of Colorado astrophysicist James Green, who designed the Cosmic Origins Spectrograph, is swinging for less than confirming the shape, age and dimensions of this cosmic web.

"We know the starting point and the ending point," Green said. "How do we connect the dots historically to get to the universe today?"

To see more distant — and hence ancient — ultraviolet light, Green designed an instrument to be 30 times more sensitive than anything that had flown before.

Alan Stern, a Boulder Southwest Research Institute planetary scientist and member of the COS science team, said the advantages are as much about speed as distance.

"It means you can do in a day what used to take a month," Stern said. "For every target you look at, you can do it 30 times faster or 30 times farther in terms of sensitivity."

Combining sharper vision with speedier observation will let scientists point Hubble in hundreds of directions during the 552 orbits, each 97 minutes long, that the CU-led science team gets to control the space telescope in the three years following installation of the spectrograph.

Green describes it as throwing darts or shooting "pencil beams" through the intergalactic medium.

Attaining such sensitivity required an elegant optical design. Mirrors reflect only 80 percent of UV light, so rather than a handful of light-draining "bounces" inside the instrument, COS gets by on just one reflection.

A single, irregularly curved, mirror-like device with 3,800 unevenly spaced grooves per millimeter does it all. It corrects the infamous Hubble lens blur, disperses the light into composite spectra and corrects the aberrations intrinsic in dispersing the light, Green said.

A 7-inch detector — seven times longer than previous ones — then collects the light. It can gulp a band of spectrum five times wider than a typical detector and so can, in two snapshots, do the work of 10 exposures on a lesser detector, Green said. That adds speed.

It was a winning combination, said Dennis Ebbets, a Ball Aerospace scientist who worked on the spectrograph and other Hubble instruments since 1980.

"Call it niche science, but for what it was designed to do, it just blows away the field," Ebbets said.



SAMMY DALLAL / Daily Camera

Dr. Michael Shull, left, and James C. Green designed and tested the Cosmic Origins, a Ball Aerospace-built instrument that will help untangle the mysteries of the ancient universe. Its planned installation on the Hubble Space Telescope is a key scientific justification for the fifth and final mission to upgrade and repair Hubble.