

To the COSMIC edge

{ EXTRAGALACTIC ASTRONOMY }

Hubble captures the deepest view ever of the universe, finding 10,000 galaxies that stretch all the way back to the edge of space and time. /// BY FRANK SIETZEN, JR.

A long time ago, in a galaxy far, far away . . . When George Lucas penned the opening to his epic saga more than a quarter century ago, little did he realize that the Hubble Space Telescope one day would turn his

fantasy into reality. Or perhaps multiple realities would be closer to the truth — Hubble recently gave astronomers a spectacular view of some 10,000 ancient galaxies stretching to the edge of the visible universe.

Using a combination of the Advanced Camera for Surveys (ACS) and the Near Infrared Camera and Multi-Object Spectrometer (NICMOS), Hubble captured the deepest images ever of the cosmos. The release of these extraordinary

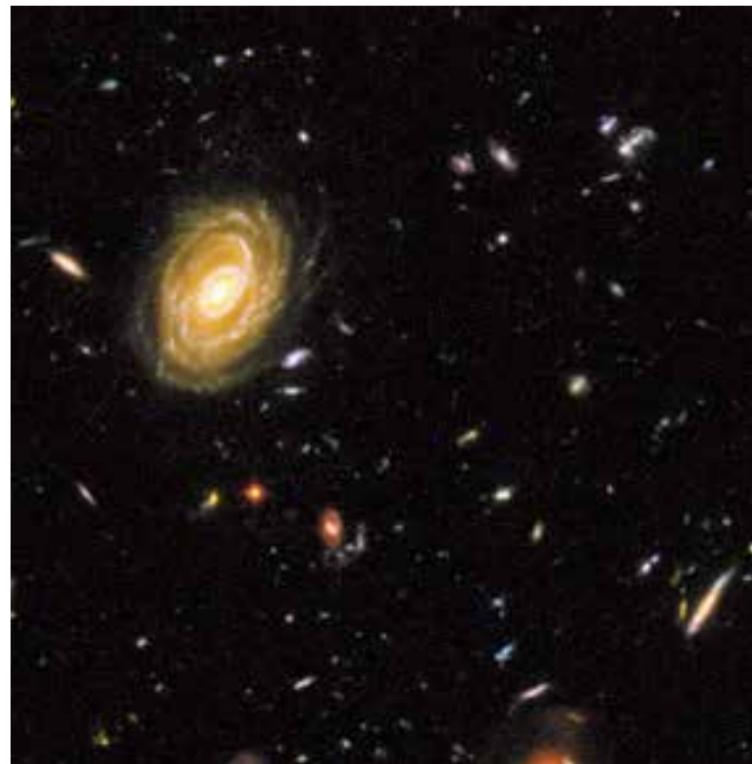


OBSERVING IN THE NEAR INFRARED, (above) Hubble sees some galaxies that existed just 400 million years after the Big Bang. The expansion of the universe shifts the light from these early galaxies into the near infrared. NASA, ESA, AND R. THOMPSON (UNIVERSITY OF ARIZONA)

THE HUBBLE ULTRA DEEP FIELD (left) provides the deepest portrait of the universe in visible light. It took Hubble nearly a million seconds to take this exposure, which records objects as faint as magnitude 30. NASA, ESA, S. BECKWITH (STScI), AND THE HUDF TEAM



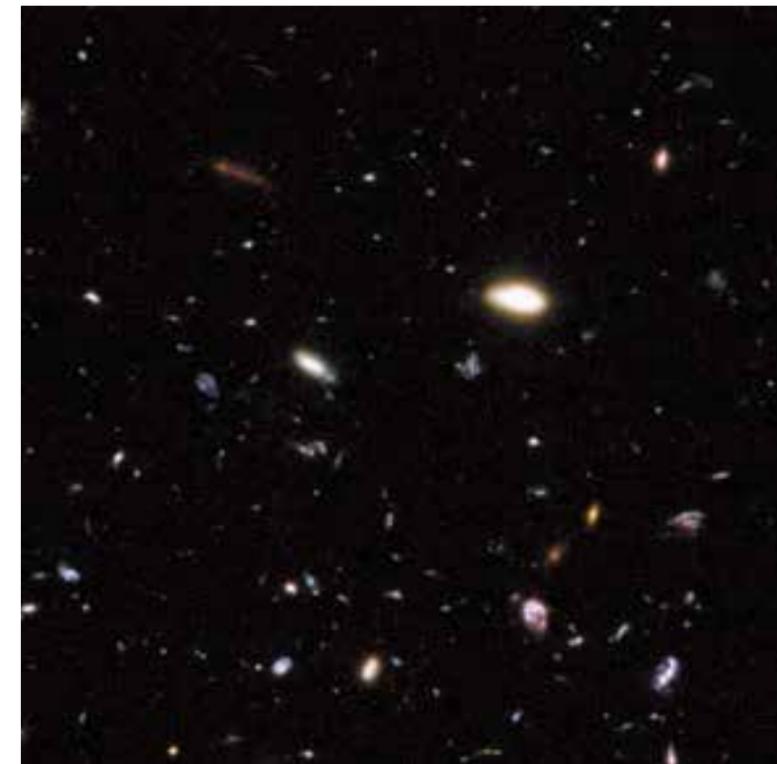
1 **THREE GALAXIES DO BATTLE** [just below center] in the rough-and-tumble early cosmos, when the universe was smaller and collisions were much more common than today.



2 **A MAJESTIC SPIRAL GALAXY** highlights this section of the Ultra Deep Field. This big, bright galaxy is one of the nearest in the field, located "only" about 1 billion light-years from Earth.



3 **CLOSE INTERACTIONS SHREDED** many of the galaxies in this part of the field, chronicling a period when the cosmos was much younger and more chaotic than what we see today.



4 **SEVERAL SMALL, REDDISH GALAXIES** in this section appear to be among the most distant ever seen in visible light, existing perhaps just 700 million years after the Big Bang.



images, known as the Hubble Ultra Deep Field (HUDF), kicked off a global race to study their contents and to understand just what they reveal.

Astronomers estimate the HUDF shows about 10,000 galaxies, some apparently among the first galaxies to emerge from the cosmic "Dark Ages." This era, marked by a cold and opaque cosmos, ended about 400 million years after the Big Bang when the first generation of stars began to reheat the universe. "Hubble takes us to within a stone's throw of the Big Bang itself," says Massimo Stiavelli, an astronomer at the Space Telescope Science Institute (STScI) in Baltimore, Maryland, and leader of the HUDF team.

"This is the deepest picture we have ever had of the universe," adds STScI director Steven Beckwith. The HUDF contains the faintest objects ever seen, reaching down to magnitude 30 — some 10 billion times fainter than the faintest objects visible with the naked eye. At that sensitivity, Hubble could pick up the glow of a firefly on the Moon.

It's also two to four times fainter than Hubble's Wide Field and Planetary Camera 2 achieved in the two landmark Hubble Deep Fields, taken in 1995 and 1998. Galaxies evolved so quickly in the early universe that the most significant changes occurred within a billion years of the Big Bang. "Where the Hubble Deep Fields showed galaxies when they were youngsters," says Stiavelli, "the Ultra Deep Field reveals them as toddlers, enmeshed in a period of rapid developmental changes."

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The ACS image was built from 800 exposures, two captured in each of 400 separate Hubble orbits around Earth. The images were taken over a four-month period that began on September 24, 2003, and ended on January 16, 2004, and represent a total exposure time of 11.3 days, or nearly 1 million seconds. (Still, that's but a small fraction of Hubble's total observing time during this period.)

Astronomers aimed Hubble at a pencil-thin slice of sky in the northeastern corner of the constellation Fornax the Furnace, a region that appears virtually empty in ground-based photographs. The square field measures 3' on a side, one-tenth the diameter of the Moon. (That's twice the field of view of the Wide Field and Planetary Camera 2, and the ACS has a greater sensitivity as well.) "It would take 13 million of these HUDF fields to cover the entire sky," says Beckwith, and nearly 1 million years of uninterrupted observing time to go as deep.

The final ACS view combines images made through four different filters. It takes astronomers back to about 700 million years after the Big Bang. Galaxies of various sizes, shapes, colors, and ages emerge in this view. The bigger and brighter galaxies — the ones nearest Earth — appear to be classic spirals and ellipticals. But lots of oddball galaxies litter the field, including some that look like toothpicks and others that resemble links on a bracelet. The smallest, reddest galaxies, about one hundred of which appear in the image, may be among the most distant ever seen.

The NICMOS image covers a slightly smaller field than the ACS image, about 2.4' on a side. It was created from views at two near-infrared wavelengths and represents 4.5 days of total exposure time.

Although the NICMOS view shows many of the same galaxies that appear in the ACS image, it also reveals some that lie even farther away. The expansion of the universe stretches much of the visible and ultraviolet light emitted by the most distant galaxies into the near-infrared part of the spectrum, where NICMOS picks it up. Rodger Thompson of the University of Arizona, principal investigator for NICMOS, thinks the image may show galaxies that existed just 400 million years after the Big Bang. If that age is confirmed, it would mean we are seeing the universe when it was just 3 percent of its present age.

In the weeks, months, and years of study ahead, astronomers hope to learn much more about the galaxies in the HUDF — and the birth and evolution of galaxies in general. The images mark the deepest penetration Hubble will ever achieve, and they will stand as the most distant views of the cosmos until the advent of NASA's James Webb Space Telescope, an infrared-optimized, 6.5-meter telescope currently scheduled for launch in 2011.

The HUDF images also gave renewed strength to efforts to prolong Hubble's life. "This is a stunning example of why the world loves Hubble," said Senator Barbara Mikulski (D-MD) at the image unveiling in Baltimore. Soon after the HUDF images were released, NASA Administrator Sean O'Keefe chartered the National Academy of Sciences to review his decision not to fly a fifth and final shuttle servicing mission to the orbiting observatory — and to see whether a robotic mission might be able to preserve the aging spacecraft. ■

To learn more about the Ultra Deep Field and Hubble's original Deep Field images, visit www.astronomy.com/toc