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Hubble telescope reveals deepest view of the Universe yet

A new deep-field photo of a 'blank spot' in space unveils thousands of previously unseen primordial galaxies.

Clara Moskowitz

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The Hubble Space Telescope has glimpsed farther away into the Universe than any observatory before, producing the first of six new 'deep field' images that show objects from the first billion years after the Big Bang.

NASA, ESA, and J. Lotz, M. Mountain, A. Koekemoer, and the HFF Team (STScI)

This long-exposure Hubble Space Telescope image of massive galaxy cluster Abell 2744 is the deepest ever made of any cluster of galaxies.

The new photo was exposed for 50 hours to gather enough light, and reveals extremely faint, tiny galaxies that may be more than 12 billion light-years away. "It is the deepest view of the Universe ever taken," says project leader Jennifer Lotz of the Space Telescope Science Institute (STScI) in Baltimore. "We're seeing things 10 or 20 times fainter than anything we've seen before." Lotz and her colleagues presented the image today here at the 223rd meeting of the American Astronomical Society.

Hubble's first Deep Field image, released in 1996, became instantly famous for revealing about 3,000 previously unknown galaxies that showed up in an apparently 'blank spot' of space when Hubble trained its camera there for dozens of hours. The newest deep fields, called Hubble Frontier Fields, use updated cameras on Hubble, and look even farther by taking advantage of the Universe's own 'natural' telescopes, called gravitational lenses.

Gravitational lenses occur when very massive objects — such as clusters of galaxies — warp spacetime around them, causing light (and anything else) traveling nearby to take a curved path. Very distant galaxies that happen to lie behind these lenses from the perspective of Earth will appear magnified and brightened because of the gravitational warping of their light. Thus, the Frontier Fields use Hubble's own magnifying abilities in combination with the serendipitous magnification offered by gravitational lenses to look for the farthest objects ever glimpsed.

The new image is preliminary. In May Hubble will collect more data on this first field, bringing the photo's total exposure time to 103 hours, and over the next three years it will examine the other five Frontier Fields, which were chosen at spots where nature's most powerful gravitational lenses lie. "We're really interested in knowing what happened in that first billion years of the Universe," Lotz says. "The thing that Frontier Fields is going to do is look for the galaxies that were basically small enough in those first billion years to turn into our Milky Way Galaxy. We want to know, when did galaxies like the Milky Way first come to be?"

The project could resolve a puzzle about when the first galaxies formed in the Universe. "Some people have claimed to see a sharp drop-off of galaxies back in time," indicating that before a certain epoch essentially no galaxies were able to form, says Dan Coe of STScI, who collaborated on the Frontier Fields project. If that is the case, it could teach us about the dark matter that appears to contribute most of the matter in the Universe. Galaxies are thought to form inside clouds of dark matter, and the properties of whatever makes up this dark matter would have determined when it first clumped into clouds and how big they were, enabling the first galaxies to form. "The Frontier Fields are going to determine fairly definitively one way or the other whether there is a sharp drop-off," Coe says.

The new photo captures 3,000 distant galaxies that are among the most ancient and distant known. To determine just how far away they are, researchers will combine the information from the Hubble images with observations taken by NASA's Spitzer and Chandra space telescopes, which see in infrared and x-ray light, respectively. These data show how much the galaxies' light has been 'Doppler shifted' toward redder wavelengths, which happens when objects are moving away from us. Because space is expanding, the farther away something is, the faster it should be receding.

The first Frontier Fields image uses the foreground galaxy cluster Abell 2744 as its gravitational lens. The photo captures not just distant galaxies behind the cluster, but galaxies that belong to Abell itself. And by measuring how the background objects have been lensed by the cluster, researchers can map out where and how much mass lies in the cluster. Because this mass includes both the visible galaxies and the unseen dark matter, the map clarifies how dark matter clumps and spreads in clusters.

As a check of this map, Steve Rodney of Johns Hopkins University plans to search for exploding stars called supernovae in the Frontier Fields. A certain class of supernovae always explodes with the same brightness (giving them the nickname 'standard candles'), so by measuring how bright they appear in the images, astronomers can tell how much their light has been magnified. "The lens modelers gave us a prediction of the magnification" based on dark matter models, says Rodney, who is not part of the official Hubble Frontier Fields team. "We get the true magnification." These checks should not only support gravitational lens models, but confirm that supernovae behaved the same early in the Universe as they do now. "We need to know," Rodney says, "that standard candles are standard throughout time."

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