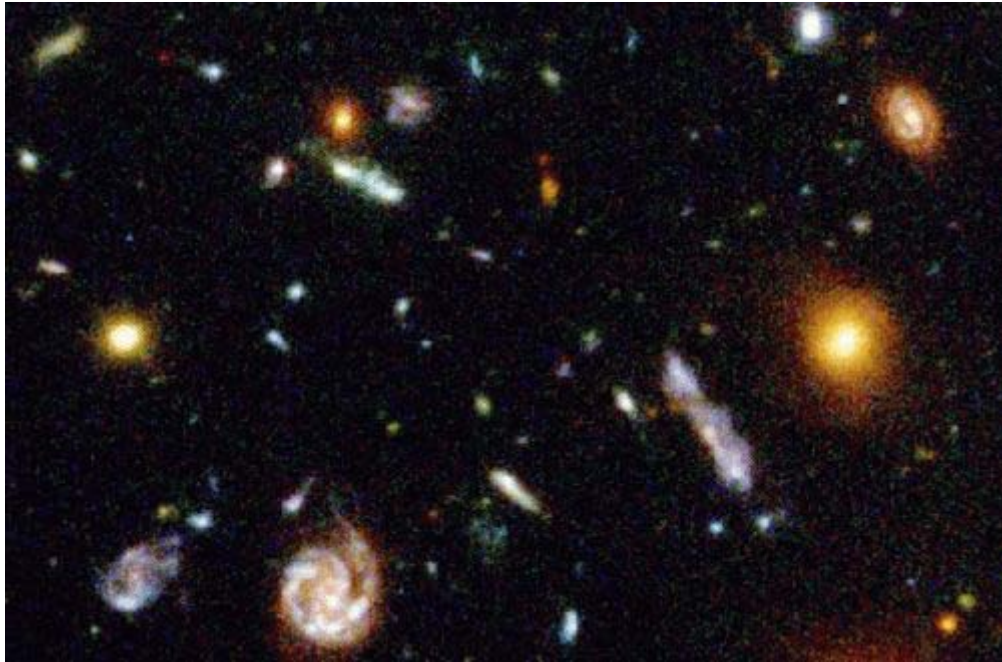


Beyond the "Hubble Deep Field" --First Galaxies of the Universe Detected

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At some stage after its birth in the big bang, the universe began create galaxies. No one knows exactly when, or how, this occurred. For that matter, astronomers do not know how the lineages of our own Milky Way galaxy and its stars trace back to those first galaxies and their first stars, but astronomers have been working hard to find out.

The Hubble Space Telescope announced in 1996 that it had stared at apparently dark sky for ten days at optical wavelengths, long enough to acquire a picture of the very distant universe. The resultant iconic image, the Hubble Deep Field (HDF), reveals galaxies that are so far away that they existed when the universe was less than about 5% of its present age of 14 billion years.

The faintest and reddest objects in the image above are likely the oldest galaxies ever identified, having formed between only 600–900 million years after the Big Bang. The image shows thousands of galaxies, some more than 12 billion years old. The field view of this image would fit behind a grain of sand held at arm's length against the sky. Almost every dot in this photo is an entire galaxy of stars and who knows what fascinating undiscovered mysteries.

Astronomers use this photo to estimate the number of galaxies in the known universe by counting the visible galaxies shown and multiplying the number of such photos it would take to make a composite of the entire sky. Their calculations estimate that the observable universe contains about 100 billion galaxies.

Since 1996 astronomers have been working to understand exactly what kinds of galaxies these remote objects are, and whether they bear any resemblance to our own Milky Way galaxy, either as it is now, or as it was when it was younger.

Harvard-Smithsonian Center for Astrophysics (cFa) astronomers along with an international team of colleagues, have just completed an unbiased, deep survey of the distant universe at infrared wavelength using the Infrared Array Camera on the Spitzer Space Telescope. The largest Spitzer science program to date, this survey explored the universe at a depth and over a large field of view never before achieved – nearly six times the area of the full moon and much larger than the original Hubble image. The survey detected galaxies as small in mass as 15% of the Milky Way, and so far away that their light has been traveling for over 12.7 billion years, over 90% of the age of the universe. Within the wide field the team discovered more than 300,000 galaxies. The new results address four major research goals: a study of galaxy evolution across this dramatic time span, the detection of galaxies with active supermassive black holes at their nuclei in this volume, and variable emission from such nuclei (thanks to the

way the survey was executed, with repeated visits to the same regions of the sky to spot changes).

Moreover, this deep, wide field allowed the team to study not only galaxies, but the infrared emission from the sky "between" these sources, the so-called diffuse component. Remarkably, the study found that while nearly half of the cosmic infrared light comes from distant galaxies, the other half comes from this diffuse background component whose origin is still not known, though some speculate that it may include light from ensemble of even smaller galaxies. This legacy survey will provide a basis for new research activity for years to come.

The famous Hubble deep field of galaxies as seen below in the infrared at a wavelength of 3.6 microns. The new SEDS project that has observed this region has also studied many other deep extragalactic fields, covering a total area nearly six times that of the full moon.

