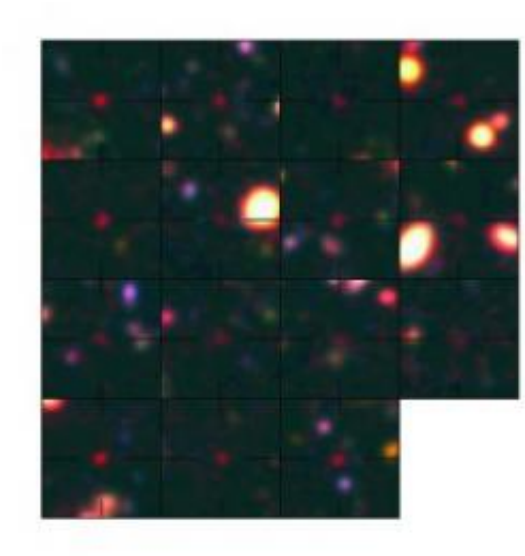
'Dropouts' pinpoint earliest galaxies

November 6 2009



This is a composite of false color images of the galaxies found at the early epoch around 800 million years after the Big Bang. The upper left panel presents the galaxy confirmed in the 787 million year old universe. These galaxies are in the Subaru Deep Field. Credit: These images are created by M. Ouchi et al., which are the reproduction of Figure 3 in the *Astrophysical Journal* December 2009 issue.

Astronomers, conducting the broadest survey to date of galaxies from about 800 million years after the Big Bang, have found 22 early galaxies and confirmed the age of one by its characteristic hydrogen signature at 787 million years post Big Bang. The finding is the first age-confirmation of a so-called dropout galaxy at that distant time and pinpoints when an era called the reionization epoch likely began. The

research will be published in a December issue of the *Astrophysical Journal*.

With recent technological advancements, such as the Wide-Field Camera 3 on the Hubble Space Telescope, there has been an explosion of research of the reionization period, the farthest back in time that astronomers can observe.

The Big Bang, 13.7 billion years ago, created a hot, murky universe. Some 400,000 years later, temperatures cooled, electrons and protons joined to form neutral hydrogen, and the murk cleared. Some time before 1 billion years after the Big Bang, neutral hydrogen began to form stars in the first galaxies, which radiated energy and changed the hydrogen back to being ionized. Although not the thick plasma soup of the earlier period just after the Big Bang, this star formation started the reionization epoch. Astronomers know that this era ended about 1 billion years after the Big Bang, but when it began has eluded them and intrigued researchers like lead author Masami Ouchi of the Carnegie Observatories.

The U.S. and Japanese team led by Ouchi used a technique for finding these extremely distant galaxies. "We look for 'dropout' galaxies," explained Ouchi. "We use progressively redder filters that reveal increasing wavelengths of light and watch which galaxies disappear from or 'dropout' of images made using those filters. Older, more distant galaxies 'dropout' of progressively redder filters and the specific wavelengths can tell us the galaxies' distance and age. What makes this study different is that we surveyed an area that is over 100 times larger than previous ones and, as a result, had a larger sample of early galaxies (22) than past surveys. Plus, we were able to confirm one galaxy's age," he continued. "Since all the galaxies were found using the same dropout technique, they are likely to be the same age."

Ouchi's team was able to conduct such a large survey because they used a custom-made, super-red filter and other unique technological advancements in red sensitivity on the wide-field camera of the 8.3-meter Subaru Telescope. They made their observations from 2006 to 2009 in the Subaru Deep Field and Great Observatories Origins Deep Survey North field. They then compared their observations with data gathered in other studies.

Astronomers have wondered whether the universe underwent reionization instantaneously or gradually over time, but more importantly, they have tried to isolate when the universe began reionization. Galaxy density and brightness measurements are key to calculating star-formation rates, which tell a lot about what happened when. The astronomers looked at star-formation rates and the rate at which hydrogen was ionized.

Using data from their study and others, they determined that the star-formation rates were dramatically lower from 800 millions years to about one billion years after the Big Bang, then thereafter. Accordingly, they calculated that the rate of ionization would be very slow during this early time, because of this low star-formation rate.

"We were really surprised that the rate of ionization seems so low, which would constitute a contradiction with the claim of NASA's WMAP satellite. It concluded that reionization started no later than 600 million years after the Big Bang," remarked Ouchi. "We think this riddle might be explained by more efficient ionizing photon production rates in early galaxies. The formation of massive stars may have been much more vigorous then than in today's galaxies. Fewer, massive stars produce more ionizing photons than many smaller stars," he explained.

Source: Carnegie Institution