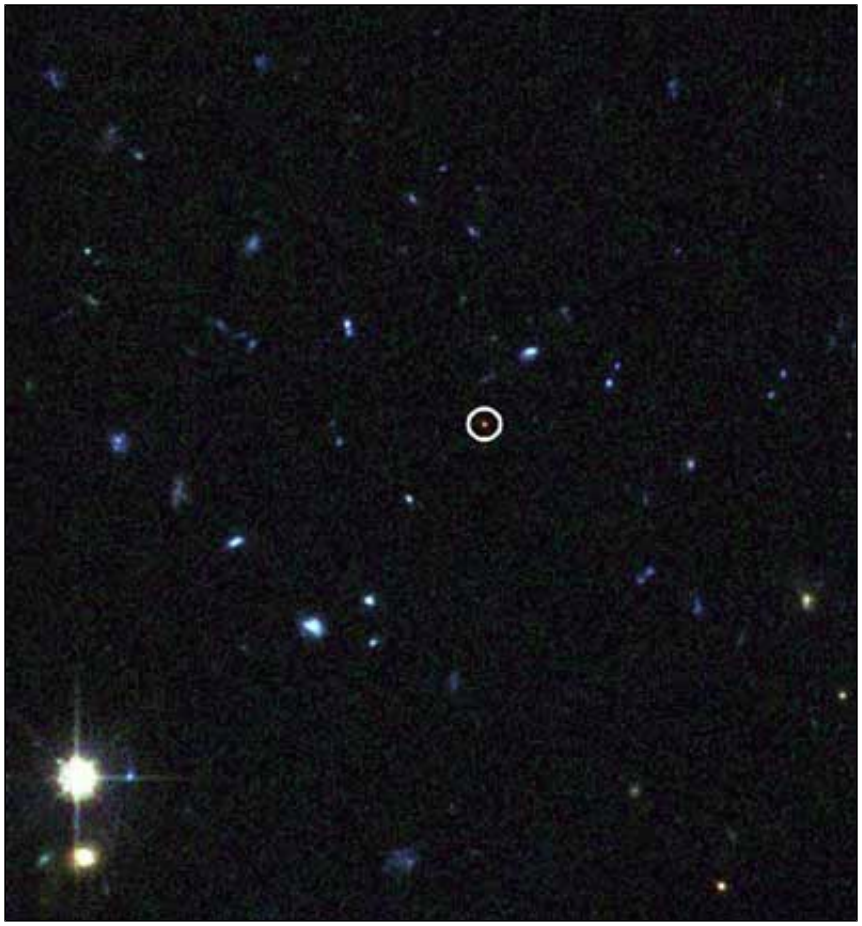
Pushing back frontiers of Universe to era of first stars

ROYAL ASTRONOMICAL SOCIETY NEWS RELEASE
Posted: March 16, 2003



Colour picture of the very distant galaxy. The blue, green and red colours are formed from the images taken through 3 filters of the Hubble Space Telescope Advanced Camera for Surveys. The redshift 5.78 galaxy is the reddest object in the field - circled in the centre. Credit: Insitute of Astronomy, Cambridge

UK astronomers Elizabeth Stanway, Andrew Bunker and Richard McMahon at the Institute of Astronomy, University of Cambridge, England, have used three of the most powerful telescopes in existence to identify some of the farthest galaxies yet seen. But at the same time, they have encountered a cosmic conundrum: it looks as if there were fewer galaxies forming stars at this early stage in the history of the Universe than in the more recent past. Their results, which will be published in the Monthly Notices of the Royal Astronomical Society, show for the first time, that astronomers may be probing back to the era

when the first stars and galaxies were forming.

Stanway, Bunker and McMahon used the unique power of the Hubble Space Telescope and analysed publicly-available images taken in the direction of the southern hemisphere constellation of Fornax (the Oven) with the new Advanced Camera for Surveys as part of the 'Great Observatory Origins Deep Survey' (GOODS) project. They identified half a dozen objects likely to be galaxies 95 per cent of the way across the observable Universe. The redshifts of these galaxies are about 6 and they are so far away that radiation from them has taken about 13 billion years to reach us. They existed when the Universe was less than a billion years old and seven billion years before the Earth and Sun formed. Intervening gas clouds absorbed visible light from them long before it reached Earth but their infrared light can be detected - and it is their infrared 'colours' which lead the researchers to believe that they lie at such immense distances.

They also used infrared images taken with one of the 8-metre telescopes forming the Very Large Telescope (VLT) at the European Southern Observatory (ESO) in Chile to study these galaxies. "The ESO pictures allowed us to distinguish very distant galaxies at the edge of the observable Universe from objects nearby," said graduate student Elizabeth Stanway, who has identified the galaxies as part of her research for a doctorate in astrophysics at Cambridge.

Having drawn up a list of objects that could be remote galaxies, the astronomers then turned to one of two Keck telescopes, which are the largest in the world and are at the top of the 14000ft mountain of Mauna Kea in Hawaii. Working with California astronomers Professor Richard Ellis (Caltech) and Dr Patrick McCarthy (Carnegie Observatories) they took a spectrum of one of them. They saw the signature of hydrogen gas glowing as it is illuminated by hot, newly-born stars, and measured the redshift to be 5.78. "This galaxy is in the process of giving birth to stars - each year it converts a mass of gas more than 30 times that of our Sun into new stars", according to research astronomer Dr. Andrew Bunker. These additional results have recently been submitted to the Monthly Notices of the Royal Astronomical Society.

"Using the Keck, was very important as it showed that this population of objects discovered by the Hubble Space Telescope really is incredibly distant", said Andrew Bunker, who was part of the team which did the observing in Hawaii. "The galaxy we have proved to be very distant is only 1000 light years across. This is very small compared to our own galaxy, the Milky Way, which is 100 times larger" added

Elizabeth Stanway.

But the Cambridge team have also found a cosmic puzzle: on the basis of their sample, they can calculate how may galaxies there are involved in the rapid formation of stars in the very distant universe (redshift 6). They have compared the answer with previous work looking at nearer galaxies, with redshifts around 4. It seems that there are fewer of these galaxies early in the history of the Universe, compared to more recent times.

Theoretical predictions for the star formation history of the universe are highly uncertain, which is why this observational work is essential. "It could be that we are seeing some of the first galaxies to be born", said Richard McMahon, "The light from these first stars to ignite could have ended the Dark Age of the Universe as the galaxies 'turn on', and might have caused the gas between the galaxies to be blasted by starlight - the 'reionization' which has recently been detected in the cosmic microwave background by the WMAP satellite". The results of the Cambridge group combined with the recent results from WMAP satellite complement each other and show that the Dark Age ended sometime between 200 and 1000 million years after the Big Bang with the formation of the first stars.

This team of astronomers are currently building a new instrument in Cambridge called 'DAZLE', which will probe even earlier in the history of the Universe and shed new light on the 'Dark Ages'.

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