Old galaxies stick together in the young universe

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UK astronomers have developed the most sensitive infrared map of the distant universe ever produced, revealing the origins of the most massive galaxies in the cosmos.

Using images obtained with the United Kingdom Infra-Red Telescope (UKIRT), astronomers combined data over a period of three years. This produced a map encompassing more than 100,000 galaxies over an area of sky four times the size of the full moon.

As light from the far reaches of the universe takes so long to reach observers on Earth, UKIRT allows astronomers to look back in time — more than ten billion years — producing images of the galaxies' infancy. The image is so large and so deep that thousands of galaxies can be studied at these early epochs for the first time.

By observing these galaxies at the infrared wavelength, astronomers can now peer even further back in time — as light is shifted towards the redder wavelength as it travels through the expanding universe.

Researchers at The University of Nottingham led the study, which also produced convincing evidence that galaxies which look old early in the history of the Universe reside in enormous clouds of invisible dark matter and will eventually evolve into the most massive galaxies that exist in the present day.

The distant galaxies identified are considered elderly because they are

rich in old, red stars. But because the light from these systems has taken up to 10 billion years to reach Earth, they are seen as they appeared in the very early Universe, just four billion years after the Big Bang. The presence of such fully-evolved galaxies so early in the life of the cosmos is hard to explain and has been a major puzzle to astronomers studying how galaxies form and evolve.

The team used the deep UKIRT images to estimate the mass of the dark matter surrounding the old galaxies by measuring how strongly the galaxies cluster together. All galaxies are thought to form within massive halos of dark matter which collapse under their own gravity from a smooth distribution of matter after the Big Bang.

These halos are invisible to normal telescopes but their mass can be estimated through analysis of galaxy clustering.

“Luckily, even if we don't know what dark matter is, we can understand how gravity will affect it and make it clump together. We can see that the old, red galaxies clump together far more strongly than the young, blue galaxies, so we know that their invisible dark matter halos must be more massive,” said Will Hartley, PhD student at the University of Nottingham, who led the work into the clustering of old galaxies.

The halos surrounding the old galaxies in the early Universe are found to be extremely massive, containing material which is up to one hundred thousand billion times the mass of our Sun. In the nearby Universe, halos of this size are known to contain giant elliptical galaxies, the largest galaxies known.

“This provides a direct link to the present day Universe,” says Hartley, "and tells us that these distant old galaxies must evolve into the most massive but more familiar elliptical-shaped galaxies we see around us today. Understanding how these enormous elliptical galaxies formed is

one of the biggest open questions in modern astronomy and this is an important step in comprehending their history."

"I would compare these observations to the ice cores drilled deep into the Antarctic," said Dr Sebastien Foucaud, who led the building of the new images into a map. "Just as they allow us to peer back in time, our ultra-deep image allows us to look back and observe galaxies evolving at different stages in cosmic history, all the way back to just one billion years after the big bang.

"We see galaxies ten times the mass of the Milky Way already in place at very early epochs. Now, for the first time, we are sampling a large enough volume of the distant universe to be able to see them in sufficient numbers and really pin down when they were formed."

Will Hartley and Dr Foucaud presented their work at this week's National Astronomy Meeting held by the Royal Astronomical Society. They were joined by Dr Omar Almaini, Reader in Astronomy at the University and overall leader of the survey team.

Dr Almaini said: "We are leading the world with this project, and there is much more to come. We will continue taking data over the next few years, which will detect galaxies in the ever more distant Universe."

The old galaxies were identified from images taken as part of the Ultra-Deep Survey (UDS), one element of a five-part project, the UKIRT Infrared Deep Sky Survey (UKIDSS), which commenced in 2005. UKIRT is the world's largest telescope dedicated solely to infrared astronomy, sited near the summit of Mauna Kea, Hawaii, at an altitude of 4194 metres (13760 feet) above sea level.

Source: University of Nottingham