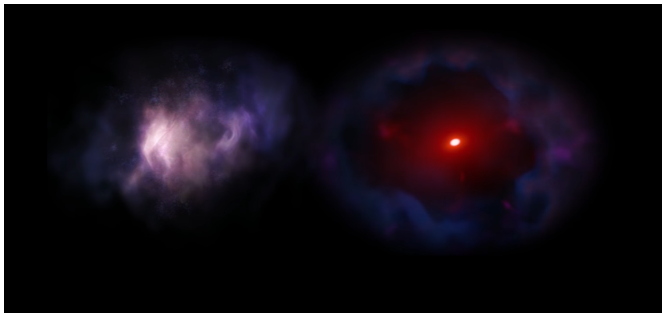
The monster galaxy that died too quickly

6 April 2017



An international team of astronomers has, for the first time, spotted a massive, inactive galaxy from a time when the Universe was only 1.65 billion years old.

Astronomers expect most galaxies from this epoch to be low-mass minnows, busily forming stars. However, this galaxy is 'a monster' and inactive, according to Professor Karl Glazebrook, Director of Swinburne's Centre for Astrophysics and Supercomputing, who led the team.

The researchers found that within a short time period this massive galaxy, known as ZF-COSMOS-20115, formed all its stars (three times more than our Milky Way today) through an extreme star-burst event. But it stopped forming stars only a billion years after the Big Bang to become a quiescent or 'red and dead' galaxy – common in our Universe today, but not expected to exist at this ancient epoch.

The galaxy is also small and extremely dense, it has 300 billion stars crammed into a region of space about the same size as the distance from the Sun to the nearby Orion Nebula.

Astrophysicists are still debating just how galaxies stop forming stars. Until recently, models suggested dead galaxies or 'red nuggets' such as this should only exist from around three billion years after the Big Bang.

"This discovery sets a new record for the earliest massive red galaxy. It is an incredibly rare find that poses a new challenge to galaxy evolution models to accommodate the existence of such galaxies much earlier in the Universe," Professor Glazebrook says.

This research builds on an earlier Swinburne study that suggested such dead galaxies could exist based on finding dim red objects in extremely deep near-infrared images.

In this latest study, astronomers used the W M Keck telescopes in Hawai'i to confirm the signatures of these galaxies, through the new and unique MOSFIRE spectrograph. They took deep spectra at near-infrared wavelengths to seek out the definitive features signifying the presence of old stars and a lack of active star formation.

"We used the most powerful telescope in the world, but we still needed to stare at this galaxy for more than two nights to reveal its remarkable nature," co-author Professor Vy Tran, from Texas A&M University, says.

Even with large telescopes such as the Keck with a 10 metre mirror, a long viewing time is required to detect absorption lines which are very weak compared to the more prominent emission lines generated by star-forming active galaxies.

"By collecting enough light to measure this galaxy's spectrum, we decipher the cosmic narrative of what stars and elements are present in these galaxies and construct a timeline of when they formed their stars," Professor Tran says.

The observed star-formation rate of this galaxy produces less than one fifth the mass of the Sun a year in new stars, but at its peak 700 million years previously this galaxy formed 5000 times faster.

"This huge galaxy formed like a firecracker in less than 100 million years, right at the start of cosmic history," Professor Glazebrook says.

"It quickly made a monstrous object, then just as suddenly it quenched and turned itself off. As to how it did this we can only speculate. This fast life and death so early in the Universe is not predicted by our modern galaxy formation theories."

Co-author Dr Corentin Schreiber of Leiden University, who first measured the spectrum, speculates that these early firecrackers are obscured behind a veil of dust and that future observations using sub-millimetre wave telescopes will spot these.

"Sub-millimetre waves are emitted by the hot dust which blocks other light and will tell us when these firecrackers exploded and how big a role they played in developing the primordial universe," says Dr Schreiber.

With the launch of the James Webb Space Telescope in 2018, astronomers will be able to build up large samples of these dead galaxies due to its high sensitivity, large mirror, and the advantage of no atmosphere in space.

This research has been published in *Nature*.

More information: A massive, quiescent galaxy at a redshift of 3.717, *Nature*, nature.com/articles/doi:10.1038/nature21680

Provided by Swinburne University of Technology