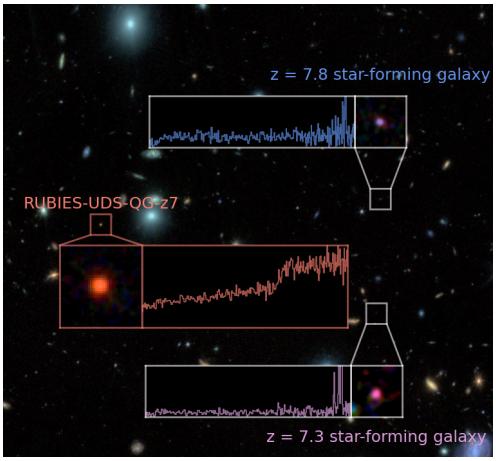
UNIVERSITÉ DE GENÈVE

PRESS RELEASE

Geneva | 2 April 2025

Galaxies die earlier than expected

An international team led by UNIGE shows that red and dead galaxies can be found only 700 million years after the Big Bang, indicating that galaxies stop forming stars earlier than predicted by models.



Three spectra taken by the JWST/NIRSpec superimposed on an image taken by the JWST/NIRCam, two instruments on board the James Webb Space Telescope. The record galaxy is shown in the middle. It appears in red in the image and its spectrum decreases towards the left (short wavelengths). For comparison, the spectra at the top and bottom, in blue and violet, show typical star-forming galaxies at a similar time in cosmic history.

Pictures

For a long time, scientists thought that only actively star-forming galaxies should be observed in the very early Universe. The James Webb space telescope now reveals that galaxies stopped forming stars earlier than expected. A recent discovery by an international team, led by astronomers from the University of Geneva (UNIGE), deepens the tension between theoretical models of cosmic evolution and actual observations. Among hundreds of spectra obtained with the Webb program RUBIES, the team has found a record-breaking galaxy that had already stopped forming stars during an epoch where galaxies are normally growing very rapidly. This study is published in the *Astrophysical Journal*.

In the early Universe, a typical galaxy accretes gas from the surrounding intergalactic medium and turns that gas into stars. This process increases its mass, leading to even more efficient gas accretion and accelerated star formation. However, galaxies do not grow indefinitely, due to a process astronomers refer to as “quenching”.

In the local Universe, about half of the observed galaxies have stopped forming stars — they have quenched and ceased growing. Astronomers refer to them as quiescent, quenched, or “red and dead” galaxies. They appear red because they no longer contain young, bright blue stars — only older, smaller red stars remain.

A particularly high fraction of quiescent galaxies is found among massive galaxies, which are often observed to have elliptical morphologies. It normally takes a long time to form such red and dead galaxies because they must first build up a large number of stars before the star-formation process finally shuts down. It is still a major puzzle what actually causes quenching in galaxies. “Finding the first examples of massive quiescent galaxies (MQGs) in the early Universe is critical as it sheds light on their possible formation mechanisms”, says Pascal Oesch, associate professor in the Department of Astronomy at the UNIGE Facutly of Science and co-author of the paper. The hunt for such systems has thus been a major goal of astronomers for years.

Observations at odds with theoretical expectations

With advancing technology, particularly near-infrared spectroscopy, astronomers have confirmed massive quiescent galaxies (MQGs) at increasingly earlier cosmic times. Their inferred abundance has been challenging to reconcile with theoretical models of galaxy formation, which predict that such systems should take longer to form. With the James Webb space telescope (JWST), this tension has been pushed

to a redshift of 5 (1.2 billion years after the Big Bang), where several MQGs have been confirmed in recent years. The new study led by UNIGE reveals that these galaxies formed even earlier and more rapidly than previously thought.

In JWST Cycle 2, the wide-area program RUBIES (the Red Unknowns: Bright Infrared Extragalactic Survey), one of the largest European-led programs for extragalactic research using the NIRSpec instrument, has obtained spectroscopic observations of several thousand galaxies, including hundreds of newly discovered sources from early JWST imaging data.

A record holder "dead" galaxy

Among these novel spectra, scientists identified the most distant MQG found to date, with a spectroscopic redshift of 7.29, just ~700 million years after the Big Bang. The NIRSpec/PRISM spectrum reveals a surprisingly old stellar population in such a young Universe. Detailed modelling of the spectrum and imaging data shows that the galaxy formed a stellar mass of more than 10 billion (10^{10}) solar masses within the first 600 million years after the Big Bang, before rapidly ceasing star formation, thus confirming its quiescent nature.

"The discovery of this galaxy, named RUBIES-UDS-QG-z7, implies that massive quiescent galaxies in the first billion years of the Universe are more than 100 times more abundant than predicted by any model to date", says Andrea Weibel, PhD student in the Department of Astronomy at the UNIGE Faculty of science and first author of the paper. This, in turn, suggests that key factors in theoretical models (e.g., the effects of stellar winds, and the strength of outflows powered by star formation and massive black holes) may need to be revisited. Galaxies died much earlier than these models can predict.

Insights into the cores of giant galaxies

Finally, the small physical size of RUBIES-UDS-QG-z7, measured at just ~650 light-years, implies a high stellar mass density comparable to the highest central densities observed in quiescent galaxies at slightly lower redshifts (z ~2–5). These galaxies are likely to evolve into the cores of the oldest and most massive elliptical galaxies in the local Universe. "The discovery of RUBIES-UDS-QG-z7 provides the first strong evidence that the centers of some nearby massive ellipticals may have already been in place since the first few hundred million years of the Universe", concludes Anna de Graaff, principal investigator of the RUBIES program, postdoctoral researcher at the Max Planck Institute for Astronomy in Heidelberg and second author of the paper.

contact

Andrea Weibel
PhD student
Department of Astronomy
Faculty of Science
UNIGE
+41 22 379 23 66
Andrea.Weibel@unige.ch

Pascal Oesch
Professor
Department of Astronomy
Faculty of Science
UNIGE
+41 22 379 24 66
Pascal.Oesch@unige.ch

DOI: 10.3847/1538-4357/adab7a

UNIVERSITÉ DE GENÈVE
Communication Department
24 rue du Général-Dufour
CH-1211 Geneva 4

Tel. +41 22 379 77 17

media@unige.ch
www.unige.ch