

Scientists discover brightest early galaxy and likely first generation stars

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labelled CR7, is three times brighter than the brightest distant galaxy known up to now. Credit: David Sobral

Astronomers using several of the largest telescopes on Earth and space have discovered the brightest galaxy yet found in the early Universe and have strong evidence that examples of the first generation of stars lurk within it. The results have been accepted for publication in *The Astrophysical Journal*.

The team's expansive study was made using the 10-meter W. M. Keck Observatory, the 8.2-meter ESO Very Large Telescope and Subaru Telescope, as well as the NASA/ESA Hubble Space Telescope. The team discovered—and confirmed—a number of surprisingly bright very young galaxies.

A team—led by David Sobral from the Institute of Astrophysics and Space Sciences, the Faculty of Sciences of the University of Lisbon in Portugal, and Leiden Observatory in the Netherlands—peered back into the ancient Universe, to the reionization period approximately 800 million years after the Big Bang. Instead of conducting a narrow and deep study of a small area of the sky, the team broadened their scope to produce the widest survey of very distant galaxies ever attempted.

Astronomers have long theorized the existence of a first generation of stars known as Population III stars that were born out of the primordial material from the Big Bang. All the heavier chemical elements essential to life—including oxygen, nitrogen, carbon and iron—were forged in the bellies of stars. This means the first stars must have formed out of the only elements to exist prior to stars: hydrogen, helium and trace amounts of lithium.

These massive, brilliant, and previously purely theoretical objects were the creators of the first heavy elements in history—the elements necessary to forge the stars around us today, the planets that orbit them, and life as we know it. The newly found galaxy, named CR7, is three times brighter than the brightest distant galaxy known up to now.

Scientists theorized these Population III stars would have been enormous: several hundred or even a thousand times more massive than the Sun; blazing hot, and transient; and exploding as supernovae after only about two million years. But until now, the search for physical proof of their existence had been inconclusive.

In addition to CR7 being by far the brightest galaxy ever observed at this stage in the Universe, further inspection provided additional exciting news.

"Keck Observatory was tremendously important in spectroscopically confirming what are now the most luminous of these distant sources, including the most luminous, the CR7 galaxy (COSMOS Redshift 7)," said Sobral. "Impressively, the Keck II telescope fitted with the DEIMOS instrument spectroscopically confirmed CR7 in 15 minutes, even though the galaxy is 13 billion light years away."

The X-shooter and SINFONI instruments on the VLT were used to find strong ionised helium emission in CR7 but—crucially and surprisingly—no sign of any heavier elements in a bright pocket in the galaxy. This meant the team had discovered the first good evidence for clusters of Population III stars that had ionised gas within a galaxy in the early Universe.

"The discovery challenged our expectations from the start," Sobral said, "as we didn't expect to find such a bright galaxy. Then, by unveiling the nature of CR7 piece by piece, we understood that not only had we found

by far the most luminous distant galaxy, but also started to realize that it had every single characteristic expected of Population III stars. Those stars were the ones that formed the first heavy atoms that ultimately allowed us to be here. It doesn't really get any more exciting than this."

Within CR7, bluer and somewhat redder clusters of stars were found, indicating that the formation of Population III stars had occurred in waves—as had been predicted. What the team directly observed was the last wave of Population III stars, suggesting that such stars should be easier to find than previously thought: they reside amongst regular stars, in brighter galaxies, not just in the earliest, smallest, and dimmest galaxies, which are so faint as to be extremely difficult to study.

"I have always wondered where we come from," said Jorryt Matthee, second author of the paper. "Even as a child I wanted to know where the elements come from: the calcium in my bones, the carbon in my muscles, the iron in my blood. I found out that these were first formed at the very beginning of the Universe, by the first generation of stars. With this discovery, remarkably, we are starting to actually see such objects for the first time."

Further observations with the VLT, ALMA, and the NASA/ESA Hubble Space Telescope are planned to confirm beyond doubt that what has been observed are Population III stars, and to search for and identify further examples.

The W. M. Keck Observatory operates the largest, most scientifically productive telescopes on Earth. The two, 10-meter optical/infrared telescopes near the summit of Mauna Kea on the Island of Hawaii feature a suite of advanced instruments including imagers, multi-object spectrographs, high-resolution spectrographs, integral-field spectrographs and world-leading laser guide star adaptive optics systems.

DEIMOS (the DEep Imaging and Multi-Object Spectrograph) boasts the largest field of view (16.7 arcmin by 5 arcmin) of any of the Keck instruments, and the largest number of pixels (64 Mpix). It is used primarily in its multi-object mode, obtaining simultaneous spectra of up to 130 galaxies or stars. Astronomers study fields of distant galaxies with DEIMOS, efficiently probing the most distant corners of the universe with high sensitivity.

More information: This research was [presented in a paper](#) entitled "Evidence for PopIII-like stellar populations in the most luminous Lyman- α emitters at the epoch of re-ionisation: spectroscopic confirmation", by D. Sobral, et al., is accepted for publication in *The Astrophysical Journal*.

Provided by W. M. Keck Observatory

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