

Astrowatch

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VLT sees evidence for first-generation stars

Astronomers using ESO's Very Large Telescope (VLT) have discovered a very bright galaxy in the early universe, and found strong evidence that it contains first-generation stars. These massive luminous stars – previously purely theoretical – are made of primordial material from the Big Bang, and produced the first heavy elements. The newly found galaxy is three times brighter than the brightest distant galaxy known up to now.

Astronomers have long theorized the existence of a first generation of stars – known as Population III stars – born out of hydrogen, helium and trace amounts of lithium, the only elements produced by Big Bang nucleosynthesis. All of the heavier chemical elements, such as oxygen, nitrogen, carbon and iron, were forged by nuclear fusion in the cores of stars. The Population III stars would have been enormous – several hundred or even a thousand times more massive than the Sun. They would have exploded as supernovae after only about 2 million years, which is less than a thousandth of the Sun's lifetime.

A team led by David Sobral, of the University of Lisbon and Leiden Observatory, has used the VLT to peer back into the ancient universe, to a period known as re-ionization, approximately 800 million years after the Big Bang. Instead of conducting a narrow and deep study of a small area of the sky, they broadened their scope to produce the widest survey of very distant galaxies ever attempted. Their



Artist's impression of CR7, a very distant galaxy displaying three main stellar clusters at different stages of evolution. One of them is likely to consist of first-generation stars. (Image credit: ESO/M Kornmesser.)

expansive study was made using the VLT, with help from the W M Keck Observatory and the Subaru Telescope, as well as the NASA/ESA Hubble Space Telescope. The team discovered and confirmed a number of surprisingly bright, very young galaxies at a redshift, z , of around seven. One of these, labelled CR7 – for COSMOS Redshift 7, but also as an allusion to the footballer Cristiano Ronaldo, who is known as CR7 – is by far the brightest galaxy ever observed so early in the history of the universe.

The X-shooter and SINFONI instruments on the VLT found strong ionized-helium

emission in CR7 but, crucially and surprisingly, no sign of any heavier elements in a bright area of the galaxy. This suggests that the team has discovered the first evidence for clusters of Population III stars that had ionized gas within a galaxy in the early universe. Bluer and somewhat redder clusters of stars were found within CR7, 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 among 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.

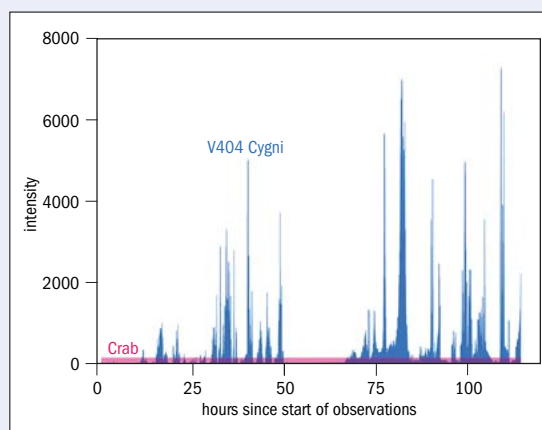
The team considered two alternative theories: that the source of the light was either an active galactic nuclei, or Wolf–Rayet stars. The lack of heavy elements, together with other evidence, strongly refutes both these theories. The team also considered that the source may be a direct-collapse black hole, which would itself be an exotic, so far purely theoretical, object. The lack of a broad emission line, and the fact that the hydrogen and helium luminosities are much greater than what has been predicted for such a black hole, indicates that this scenario is also rather unlikely.

● Further reading

D Sobral *et al.* 2015 arXiv:1504.01734 [astro-ph. GA], to be published in *ApJ*.

Picture of the month

This graph shows variation in the X-ray luminosity of the black-hole binary system V404 Cygni, as observed with the IBIS instrument on ESA's INTEGRAL gamma-ray observatory. This system, comprising a black hole and a star orbiting one another, is located in the Milky Way Galaxy, almost 8000 light-years away in the constellation Cygnus. On 15 June, V404 Cygni started showing signs of extraordinary activity, something that had not happened since 1989. The renewed activity is likely to be caused by material slowly piling up in the disc, until eventually reaching a tipping point that dramatically changes the black hole's feeding routine for a short period. The data show repeated outbursts of X-rays on time scales shorter than an hour, something rarely seen in other black-hole systems. On these occasions, V404 Cygni becomes the brightest object in the X-ray sky, up to 50 times brighter than the level shown with the pink line, which refers to the Crab Nebula, the brightest steady source in the high-energy sky. (Image credit: ESA/INTEGRAL/IBIS/ISDC.)



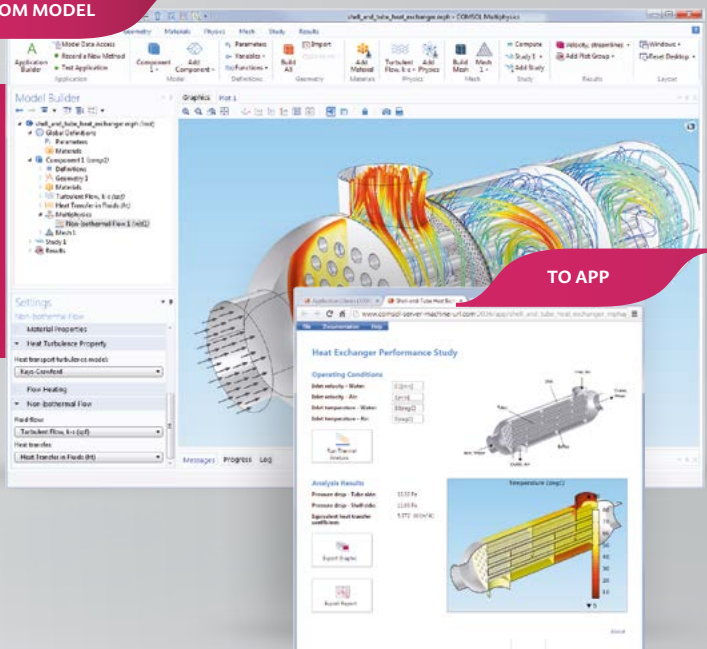
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