

Ancient stardust sheds light on the first stars

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Credit: University College London

A huge mass of glowing stardust in a galaxy seen shortly after the Universe's formation has been detected by a UCL-led team of astronomers, providing new insights into the birth and explosive deaths of the very first stars.

The galaxy is the most distant object ever observed by the Atacama Large Millimeter/submillimeter Array (ALMA) and was seen when the Universe was only four percent of its present age, at about 600 million years old, when the first stars and galaxies were forming. It is also the most distant galaxy in which dust and oxygen has been detected.

The study, funded by the European Research Council and published today in the *Astrophysical Journal Letters*, observed A2744_YD4, the youngest and most remote galaxy ever seen using ALMA.

The team, led by Dr Nicolas Laporte (UCL Physics & Astronomy), was surprised to find that this

youthful galaxy, whose enormous distance was confirmed with the X-Shooter instrument on ESO's Very Large Telescope, contained an abundance of [interstellar dust](#) formed by the deaths of an earlier generation of stars.

Study lead, Dr Nicolas Laporte, said: "Not only is A2744_YD4 the most distant galaxy yet observed by ALMA, but the detection of so much dust indicates early supernovae must have already polluted this galaxy."

Cosmic dust is mainly composed of silicon, carbon and aluminium, in grains as small as a millionth of a centimetre across. The chemical elements in these grains are forged inside stars and are scattered across the cosmos when the stars die, most spectacularly in supernova explosions, the final fate of short-lived, massive stars.

Today, this dust is plentiful and is a key building block in the formation of stars, planets and complex molecules; but in the early Universe, before the first generations of stars died out, it was scarce.

The observations of the dusty galaxy A2744_YD4 were made possible because this galaxy lies behind a massive galaxy cluster called Abell 2744. A phenomenon called gravitational lensing causes the cluster to act like a giant cosmic 'telescope', magnifying the more distant A2744_YD4 by about 1.8 times, allowing the team to peer far back into the early Universe.

The ALMA observations also detected the glowing emission of ionised oxygen from A2744_YD4. This is the most distant, and hence earliest, detection of oxygen in the Universe.

"The Hubble and Spitzer Space Telescopes provided us with important information about the distance of A2744_YD4, but it's only thanks to powerful instruments like X-Shooter and ALMA that we can confirm the nature of this distant dusty

galaxy," added Guido Roberts-Borsani (UCL Physics & Astronomy), PhD student and a co-author of the study.



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The detection of dust in the early Universe provides new information on when the first supernovae exploded and hence the time when the first hot stars bathed the Universe in light. Determining the timing of this 'cosmic dawn' is one of the holy grails of modern astronomy, and it can be indirectly probed through the study of early interstellar dust.

The team estimates that A2744_YD4 contained an amount of dust equivalent to 6 million times the mass of our Sun, while the galaxy's total stellar mass—the mass of all its stars—was two billion times the mass of our Sun. The team also measured the rate of star formation in A2744_YD4 and found that stars are forming at a rate of 20 solar masses per year—compared to just one solar mass per year in the Milky Way.

"This rate is not unusual for such a [distant galaxy](#), but it does shed light on how quickly the dust in A2744_YD4 formed," explained Professor Richard Ellis (ESO and UCL Physics & Astronomy), a co-author of the study. "Remarkably, the required time is only about 200 million years, so we are witnessing this galaxy shortly after its formation."

This means that significant star formation began approximately 200 million years before the epoch at which the galaxy is being observed. This provides a great opportunity for ALMA to help study the era when the first stars and galaxies 'switched on'—the earliest epoch yet probed. Our Sun, our planet and our existence are the products—13 billion years later—of this first generation of [stars](#). By studying their formation, lives and deaths, we are exploring our origins.

"With ALMA, the prospects for performing deeper and more extensive observations of similar [galaxies](#) at these early times are very promising," said Professor Ellis.

Dr Laporte concluded: "Further measurements of this kind offer the exciting prospect of tracing early [star formation](#) and the creation of the heavier chemical elements even further back into the early Universe."

More information: Dust In The Reionization Era: Alma Observations of A Z =8.38 Gravitationally Lensed Galaxy. www.eso.org/public/archives/re...eso1708/eso1708a.pdf

Provided by University College London

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