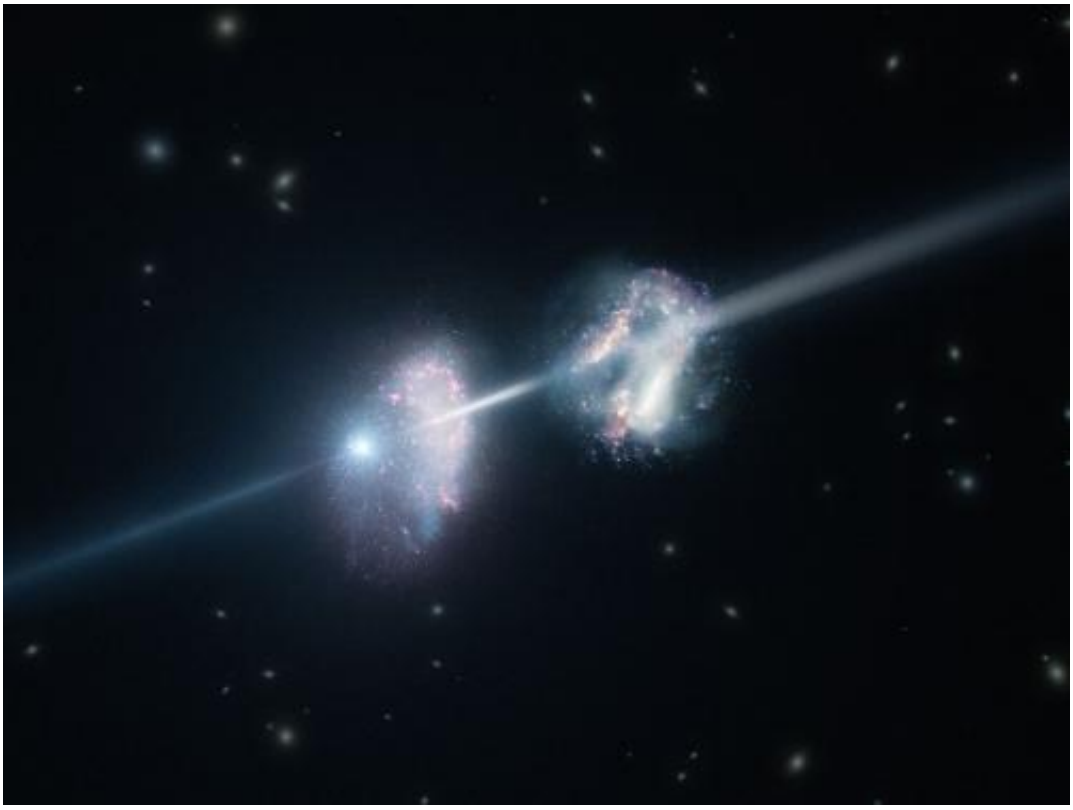
Gamma-ray burst reveals surprising ingredients of early galaxies

November 2 2011



This artist's impression shows two galaxies in the early universe. The brilliant explosion on the left is a gamma-ray burst. The light from the burst travels through both galaxies on its way to Earth (outside the frame to the right). Analysis of observations of the light from this gamma-ray burst made using ESO's Very Large Telescope have shown that these two galaxies are remarkably rich in heavier chemical elements. Credit: ESO/L. Calçada

(PhysOrg.com) -- An international team of astronomers has used the brief but brilliant light of a distant gamma-ray burst as a probe to study the make-up of very distant galaxies. Surprisingly the new observations, made with ESO's Very Large Telescope, have revealed two galaxies in the young Universe that are richer in the heavier chemical elements than the Sun. The two galaxies may be in the process of merging. Such events in the early Universe will drive the formation of many new stars and may be the trigger for gamma-ray bursts.

Gamma-ray bursts are the brightest explosions in the Universe. They are first spotted by orbiting observatories that detect the initial short burst of gamma rays. After their positions have been pinned down, they are then immediately studied using large ground-based telescopes that can detect the visible-light and infrared afterglows that the bursts emit over the succeeding hours and days. One such burst, called GRB 090323, was first spotted by the NASA Fermi Gamma-ray Space Telescope. Very soon afterwards it was picked up by the X-ray detector on NASA's Swift satellite and with the GROND system at the MPG/ESO 2.2-metre telescope in Chile and then studied in great detail using ESO's Very Large Telescope (VLT) just one day after it exploded.

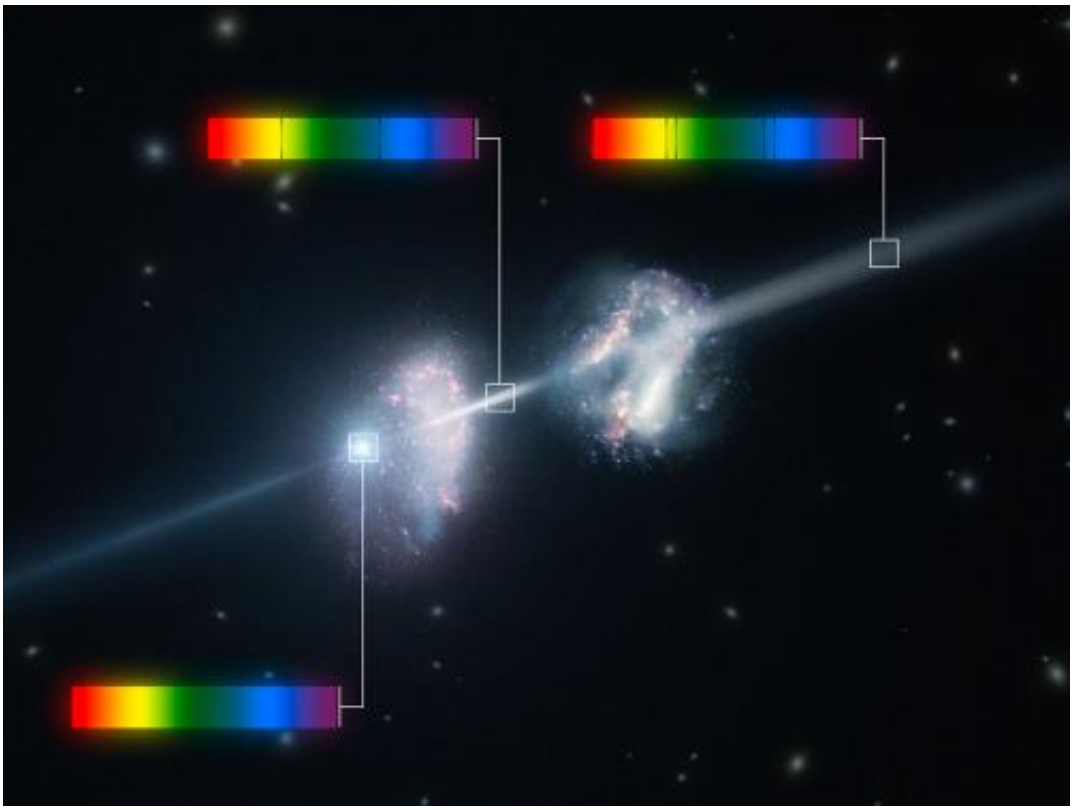
The VLT observations show that the brilliant light from the gamma-ray burst had passed through its own host galaxy and another galaxy nearby. These galaxies are being seen as they were about 12 billion years ago. Such distant galaxies are very rarely caught in the glare of a gamma-ray burst.

"When we studied the light from this gamma-ray burst we didn't know what we might find. It was a surprise that the cool gas in these two galaxies in the early Universe proved to have such an unexpected chemical make-up," explains Sandra Savaglio (Max-Planck Institute for Extraterrestrial Physics, Garching, Germany), lead author of the paper describing the new results. "These galaxies have more heavy elements

than have ever been seen in a galaxy so early in the evolution of the Universe. We didn't expect the Universe to be so mature, so chemically evolved, so early on."

As light from the gamma-ray burst passed through the galaxies, the gas there acted like a filter, and absorbed some of the light from the gamma-ray burst at certain wavelengths. Without the gamma-ray burst these faint galaxies would be invisible. By carefully analysing the tell-tale fingerprints from different chemical elements the team was able to work out the composition of the cool gas in these very distant galaxies, and in particular how rich they were in heavy elements.

It is expected that galaxies in the young Universe will be found to contain smaller amounts of heavier elements than galaxies at the present day, such as the Milky Way. The heavier elements are produced during the lives and deaths of generations of stars, gradually enriching the gas in the galaxies. Astronomers can use the chemical enrichment in galaxies to indicate how far they are through their lives. But the new observations, surprisingly, revealed that some galaxies were already very rich in heavy elements less than two billion years after the Big Bang. Something unthinkable until recently.



This artist's impression shows two galaxies in the early Universe. The brilliant explosion on the left is a gamma-ray burst. As the light from the burst passes through the two galaxies on the way to Earth (outside the frame to the right) some colours are absorbed by the cool gas in the galaxies, leaving characteristic dark lines in the spectrum. Careful study of these spectra has allowed astronomers to discover that these two galaxies are remarkably rich in heavier chemical elements. Credit: ESO/L. Calçada

The newly discovered pair of young galaxies must be forming new stars at a tremendous rate, to enrich the cool gas so strongly and quickly. As the two galaxies are close to each other they may be in the process of merging, which would also provoke star formation when the gas clouds collide. The new results also support the idea that gamma-ray bursts may be associated with vigorous massive star formation.

Energetic star formation in galaxies like these might have ceased early on in the history of the Universe. Twelve billion years later, at the present time, the remains of such galaxies would contain a large number of stellar remnants such as black holes and cool dwarf stars, forming a hard to detect population of "dead galaxies", just faint shadows of how they were in their brilliant youths. Finding such corpses in the present day would be a challenge.

"We were very lucky to observe GRB 090323 when it was still sufficiently bright, so that it was possible to obtain spectacularly detailed observations with the VLT. Gamma-ray bursts only stay bright for a very short time and getting good quality data is very hard. We hope to observe these galaxies again in the future when we have much more sensitive instruments, they would make perfect targets for the E-ELT," concludes Savaglio.

More information: This research was presented in a paper "Super-solar Metal Abundances in Two Galaxies at z ~ 3.57 revealed by the GRB 090323 Afterglow Spectrum" to appear in *Monthly Notices of the Royal Astronomical Society*.

Provided by ESO