Seeing is believing

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This image shows the afterglow of GRB 090423 (the red source in the centre) and was created from images taken at Gemini-South and the Very Large Telescope

(PhysOrg.com) -- Whenever you look up at the stars you are looking back in time, as light from even our closest neighbour, Alpha Centauri, started its journey to Earth more than four years ago. It is a phenomenon that astrophysicists Professor Malcolm Bremer and Dr Ben Maughan from the Department of Physics grapple with daily in their research into deepest space.

As telescopes become ever more powerful, we are able to observe objects closer and closer to the Big Bang. It is believed that the first stars formed when the Universe was very young - between 200 and 400 million years old - and the nearest we have got to seeing them is 630 million years from the Big Bang, when the Universe was less than five percent of its current age. The not so elegantly named 'GRB 090423' was discovered there, making it the most distant object yet seen in the Universe.

"GRB 090423 is an example of a gamma ray burst, the brightest and most violent explosions in the Universe," explains Bremer, who was involved in the observations. "The explosion, which only lasted a matter of seconds, is thought to have accompanied the catastrophic death of a very massive star. It would have been triggered by the centre of the star collapsing to form a black hole."

GRB 090423 was discovered in April 2009 by a robotic spacecraft called Swift that was launched into orbit in 2004. The discovery of such a distant gamma-ray burst confirms that massive stellar births - and deaths - occurred in the very early Universe. Gamma-ray bursts release a tremendous amount of energy in a very short time, but despite GRB 090423's brief appearance, light from the explosion still managed to get here even though it took more than 13 billion years. However, as Maughan points out, while light years are a convenient shorthand to describe the vast distances to these objects, telling us how long their light has been travelling to reach us, the Universe has been expanding during that whole period, so the Earth and these objects are now even further apart than they were when the light we see was first emitted.

GRB 090423 is the most distant object yet seen in the Universe

Closer to home is the galaxy cluster JKCS041. Because matter is not evenly distributed across the Universe, stars form into galaxies and galaxies cluster into groups, which may consist of hundreds or even thousands of galaxies, held together by a gravitational field. "You can imagine them being a bit like a swarm of bees buzzing around but not flying apart because they're held together by gravity," says Maughan. Galaxy clusters are the largest gravitationally bound objects in the Universe and at a distance of 10.2 billion light years, JKCS041 - the most distant galaxy cluster yet discovered - beats the previous record holder by about a billion light years. It sits on the cusp of the distance limit expected for a galaxy cluster, as physicists believe gravity could not have worked fast enough for them to cluster together much earlier.

JKCS041 was originally detected in 2006 in a survey using the UK's Infrared Telescope, but it

was only identified as a galaxy cluster when data from this and other telescopes were combined with data from NASA's Chandra X-ray Observatory. Galaxy clusters are composed of approximately 85% dark matter, 12% gas and 3% star material. The gas is very hot and, according to the laws of physics, it should evaporate unless there is a strong gravitational field holding it in place, in the same way that the Earth's mass provides the gravitational field that holds our atmosphere in place. The fact that the intergalactic gas does not boil off into space is evidence that there is a massive amount of unseen material - dark matter - providing the gravitational field.

The hot gas emits strong X-rays and detection of these would confirm whether JKCS041 was an established galaxy cluster or one caught in the act of forming. Maughan analysed the data and verified that the extended X-ray emission seen by Chandra meant that hot gas did indeed exist between the galaxies, as expected for a true galaxy cluster. Further study of JKCS041's characteristics - its composition, mass and temperature - will reveal valuable information about how the Universe took shape.

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Maughan was also involved in tracking down a gigantic, previously unknown, assembly of galaxies, located almost seven billion light years away. The discovery, made possible by combining two of the most powerful ground-based telescopes in the world, provides insight into the 'cosmic web' and how it formed. The most widely accepted cosmological theories predict that galactic matter clumps together on a scale even larger than galaxy clusters. In this 'cosmic web', galaxies embedded in filaments of light stretching between inky voids form a gigantic wispy structure. "These filaments are millions of light years long," explains Maughan, "creating enormous networks with massive galaxy clusters forming at the busiest intersections. Lurking like giant spiders, these clusters grow ever larger by greedily consuming the material that is funnelled on to them via the filaments."

Astronomers have struggled to determine how these structures come into existence, for although massive filamentary structures have been often observed at relatively small distances from us, solid proof of their existence in the more distant Universe has been lacking. Now, however, Maughan and the team have come a step closer to finding the evidence they need. Following the discovery of a filamentary large structure around a distant cluster of galaxies, they used two major ground-based telescopes to study this structure in greater detail. By measuring the distance from Earth to over 150 galaxies within it they obtained a three-dimensional view of the structure in which they identified several clumps of galaxies surrounding the main cluster. Some of the clumps are already feeling the fatal gravitational pull of the main cluster and will eventually fall into it. The filamentary structure is located about 6.7 billion light-years away from us and probably extends beyond the 60-million- light-year field of view probed by the team. It is the first time that such a rich and prominent structure has been observed in the distant Universe. Future observations have already been planned to obtain a definite measure of its size.

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