New window on the early Universe

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The Milky Way through the ALMA telescopic composite. Credit: ALMA (ESO/NAOJ/NRAO), C. Padilla

Scientists at the Universities of Bonn and Cardiff see good times approaching for astrophysicists after hatching a new observational strategy to distill detailed information from galaxies at the edge of the Universe. Using two world-class supercomputers, the researchers were able to demonstrate the effectiveness of their approach by simulating the formation of a massive galaxy at the dawn of cosmic time. The ALMA radio telescope – which stands at an elevation of 5,000 meters in the

Atacama Desert of Chile, one of the driest places on earth – was then used to forge observations of the galaxy, showing how their method improves upon previous efforts.

It is extremely difficult to gather information about galaxies at the edge of the Universe: the signals from these heavenly bodies "dilute" in the course of their billion-year journey through space toward earth, making them difficult observational targets.

Estimating how much molecular hydrogen is present in these galaxies is particularly challenging: the molecule emits almost no radiation. Nevertheless, Astrophysicists are keen to map the abundance of this element: molecular hydrogen is the fundamental building block for new stars; the more of it contained within a particular galaxy, the more stars that galaxy can form.

The carbon trick

Currently, astrophysicists make use of a trick to determine the abundance of molecular hydrogen in a galaxy: they first measure the amount of carbon monoxide – which emits far more light than molecular hydrogen – and then "convert" the carbon monoxide signal to an abundance of molecular hydrogen using a complex procedure. This method, however, is imprecise and prone to error.

"We were able to show that the radiation of neutral carbon is much better suited to observe very distant galaxies", says Dr. Padelis Papadopoulos from the University of Cardiff. "The measured values allow for a very precise estimation of how much molecular hydrogen is present." Unfortunately, the radiation from neutral carbon is almost entirely absorbed by water vapor in the earth's atmosphere, which acts similar to a pair of dark sunglasses when observing the carbon signal.

However, a new radio telescope in the Chilean Atacama Desert, the Atacama Large Millimeter/submillimeter Array (or ALMA), is designed with these limitations in mind. There, at an elevation of 5,000 meters, the conditions are so extremely dry that the telescope can easily pick up the interstellar radiation from carbon atoms.

Looking back 12 billion years into the past

"According to our calculations, ALMA can detect these distant galaxies, the signals of which have been traveling to us for more than 12 billion years", says Matteo Tomassetti, doctoral student of the University of Bonn and lead author of the publication. "Even more importantly: for the first time we are able to precisely determine how much molecular hydrogen is present in these galaxies."

The University of Bonn astrophysicist Professor Cristiano Porciani speaks of a new window to the early universe. "Our theoretical work will have an important impact on observational astronomy", he emphasizes. "It will help us to better understand the mysterious origin of the galaxies."

More information: M. Tomassetti, C. Porciani, E. Romano-Díaz, A. D. Ludlow, P. P. Papadopoulos: "Atomic carbon as a powerful tracer of molecular gas in the high-redshift Universe: perspectives for ALMA"; *MNRAS Letters*; doi: 10/193/mnras/slu137

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