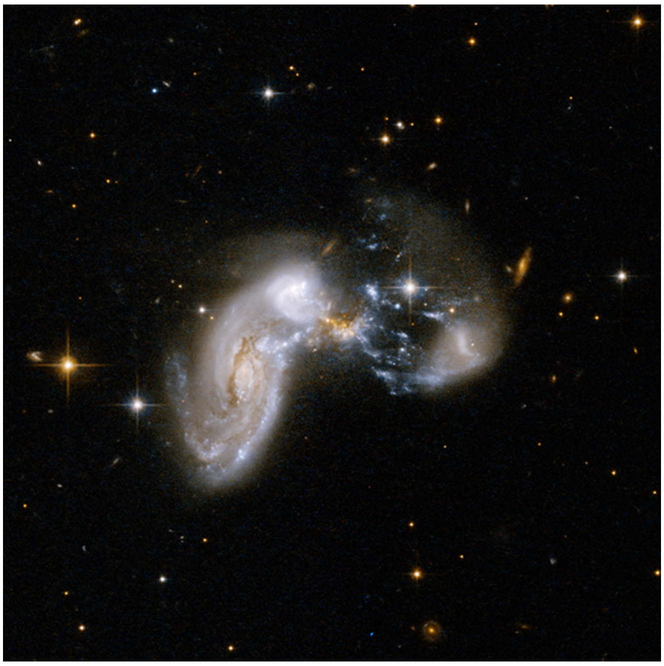
ALMA telescope unveils rapid formation of new stars in distant galaxies

14 October 2015



Example of a galaxy merger. Credit: NASA, ESA, the Hubble Heritage Team (STScI/AURA)-ESA/Hubble Collaboration and A. Evans (University of Virginia, Charlottesville/NRAO/Stony Brook University)

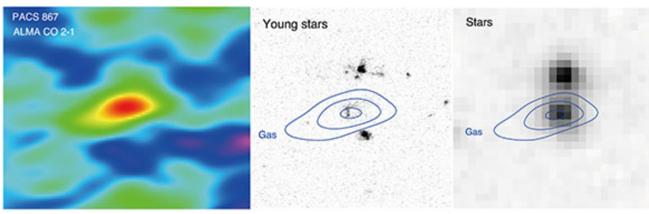
Galaxies forming stars at extreme rates nine billion years ago were more efficient than average galaxies today, researchers find.

The majority of stars have been believed to lie on a "main sequence", where the larger a galaxy's mass, the higher its efficiency to form new stars. However, every now and then a galaxy will display a burst of newly-formed stars that shine brighter than the rest. A collision between two large galaxies is usually the cause of such starburst phases, where the cold gas residing in the giant molecular clouds becomes the fuel for sustaining such high rates of star formation.

The question astronomers have been asking is whether such starbursts in the early universe were the result of having an overabundant gas supply, or whether galaxies converted gas more efficiently.

A new study to be published in *Astrophysical Journal Letters* on October 14, led by John Silverman at the Kavli Institute for the Physics and Mathematics of the Universe, studied carbon monoxide (CO) gas content in seven starburst galaxies far away from when the Universe was a young four billion years old. This was feasible by the advent of Atacama Large Millimeter Array (ALMA), located on a mountaintop plateau in Chile, which works in tandem to detect electromagnetic waves at a wavelength range in the millimeter (pivotal for studying molecular gas) and a sensitivity level that is just starting to be explored by astronomers today.

The researchers found the amount of CO-emitting gas was already diminished even though the galaxy continued to form stars at high rates. These observations are similar to those recorded for starburst galaxies near Earth today, but the amount of gas depletion was not quite as rapid as expected. This led researchers to conclude there might be a continuous increase in the efficiency depending on how high above the rate of forming stars is from the main sequence.



UV light associated with the gas is faint, but brighter in the infrared due to the presence of dust that impacts the UV more than the IR. Left: Map of the galaxy PACS-867 taken by ALMA where carbon monoxide (CO) emission shows molecular gas reservoir out of which stars form.

Center: Image taken by Hubble Space Telescope Advanced Camera for Surveys of PACS-867 showing rest-frame UV light from young stars in individual components of highly disturbed galaxies as a result of a massive merger. Location of molecular gas in Left image is overlaid (blue contours), showing where new stars are forming. Right: Spitzer Space Telescope infrared image (3.6 micron) ofPACS-867 highlights stars embedded in dust and associated with molecular gas. Credit: Left image credit: ALMA (ESO/NAOJ/NRAO), J. Silverman (Kavli IPMU),Center image credit: NASA/ESA Hubble Space Telescope, ALMA(ESO/NAOJ/NRAO), J. Silverman (Kavli IPMU), Right image credit:NASA/Spitzer Space Telescope, ALMA (ESO/NAOJ/NRAO), J. Silverman(Kavli IPMU)

This study relied on a variety of powerful telescopes available through the COSMOS survey. Only the Spitzer and Herschel Observatories could measure accurate rates of star formation, and the Subaru Telescope could confirm the nature and distance of these extreme galaxies using spectroscopy.

John Silverman comments: "These observations clearly demonstrate ALMA's unique capability to measure with ease a critical component of high redshift galaxies thus indicative of the remarkable results to come from ALMA."

More information: A higher efficiency of converting gas to stars pushes galaxies at z~1.6 well-above the star-forming main sequence, *Astrophysical Journal Letters*, 812, L23 (2015) iopscience.iop.org/article/10. … 2041-8205/812/2/L123 , arxiv.org/abs/1505.04977

Provided by Kavli Institute for the Physics and Mathematics of the Universe