SCIENTIFIC AMERICAN

News - February 10, 2010

Star Mills: Ancient Galaxies Packed More Raw Material for Stellar Formation

The rapid formation of stars billions of years ago compared with the present day appears to have resulted from larger gas reservoirs rather than from a more efficient formation process

By John Matson

The Milky Way Galaxy, to take a census view, is a populous place with a very low birthrate—it is home to hundreds of billions of stars, but only a handful of new ones appear each year. Neighboring galaxies show similar traits; accordingly, they must have once formed stars at a much more rapid clip. Across the universe, astronomers can see galaxies earlier in cosmic history, and unsurprisingly the birthrate then was much higher.

A new study shows that galaxies present just a few billion years after the big bang had much more star-forming material, in the form of molecular gas, to draw on. The finding, published in the February 11 issue of *Nature*, confirms the commonly held supposition that the vigorous star formation in the young universe largely stems from an early bounty of raw materials, rather than a more efficient process of star production. (*Scientific American* is part of Nature Publishing Group.)

Linda Tacconi, an astrophysicist at the Max Planck Institute for Extraterrestrial Physics in Garching, Germany, and her colleagues used an array of telescopes on a remote plateau in the French Alps to look for the spectroscopic evidence of carbon monoxide, a key tracer gas, in galaxies that existed roughly three billion to 5.5 billion years after the big bang. (The universe is thought to be about 13.7 billion years of age.)

In those distant galaxies, the fraction of the total galactic mass (excluding contributions from dark matter) contributed by molecular gas was several times higher than it is in the local, present-day universe. What is more, the most ancient galaxies appeared to have the highest concentrations of molecular gas.

Tacconi says that the new work confirms what many cosmologists and astronomers believed but had not proved. "I think there will be a lot of people that will be very happy with this result," she says. "The inference [from robust star formation] is that there must be a lot of material, but there's been sort of step there that's missing—the evidence of that material is what we've now been able to show."

Astronomers had been able to spot the signature of specific molecules in the early universe before, but those observations were mostly confined to extremely bright objects such as quasars. "We've been able to go back even further in time with the most luminous objects before," Tacconi says. "Now we're able to go down into what you might call more normal star-forming galaxies." She attributes the advancement in part to the development of

new, high-tech radio receivers at the Plateau de Bure Observatory, operated by the Institute of Millimeter Radioastronomy in Grenoble, France.

Neal Evans, an astronomy professor at the University of Texas at Austin, credits the researchers for broadening the observational window from the somewhat anomalous luminous events to include run-of-the-mill galaxies in the fairly young universe. "They're not the extreme things, but we still see the same pattern of having a lot of molecular gas," Evans says, calling the research by Tacconi and her colleagues "an observational tour de force."

"We knew that overall a lot of star formation went on at these redshifts," Evans says, referring to a measure of cosmological distance and time. "But we didn't know if it was all happening in a few extreme events—colliding galaxies and so on."

The Atacama Large Millimeter/Submillimeter Array (ALMA), a massive observatory now under construction five kilometers above sea level in Chile, should further illuminate the workings of distant galaxies when it opens for scientific use in 2011. "This is kind of a taste of what we're going to get with the ALMA array," Evans says. Tacconi concurs, noting that ALMA will give astronomers more precise readings of the galaxies' contents at epochs spanning the last 10 billion years or so, and may even allow the structures of those galaxies to be teased out.

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