Universe's most distant galaxy discovered

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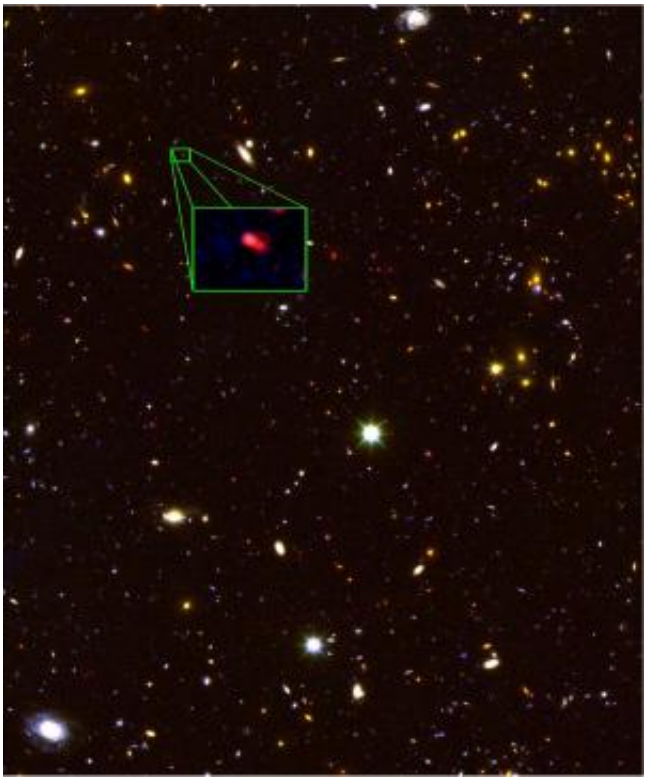

This image from the Hubble Space Telescope CANDELS survey highlights the most distant galaxy in the universe with a measured distance, dubbed z8_GND_5296. The galaxy's red color alerted astronomers that it was likely extremely far away and, thus, seen at an early time after the Big Bang. A team of astronomers including Steven Finkelstein of the University of Texas at Austin and Vithal Tilvi of Texas A&M University measured the exact distance using the Keck I telescope with the new MOSFIRE spectrograph. They found that this galaxy is seen at about 700 million years after the Big Bang, when the universe was just 5% of its current age of 13.8 billion years. Credit: V. Tilvi, Texas A&M University; S.L. Finkelstein, University of Texas at Austin; C. Papovich, Texas A&M University; CANDELS Team and Hubble Space Telescope/NASA

Texas A&M University and the University of Texas at Austin may be former football rivals, but the Lone Star State's two research giants have teamed up to detect the most distant spectroscopically confirmed galaxy ever found—one created within 700 million years after the Big Bang.

The research is published in the most recent edition of the journal *Nature*.

"It's exciting to know we're the first people in the world to see this," said Vithal Tilvi, a Texas A&M postdoctoral research associate and co-author of the paper, set to be available online after Oct. 24. "It raises interesting questions about the origins and the evolution of the universe."

The paper's lead author is Steven Finkelstein, an assistant professor at the University of Texas at Austin and 2011 Hubble Fellow who previously was a postdoctoral research associate at Texas A&M under the mentorship of Texas A&M astrophysicist Casey Papovich, who is second author as well as current mentor to Tilvi. Ten other international institutions collaborated on the effort, from California to Massachusetts and Italy to Israel.

The galaxy, known by its catalog name z8_GND_5296, fascinated the researchers. Whereas our home, the Milky Way, creates about one or two Sun-like stars every year or so, this newly discovered galaxy forms around 300 a year and was observed by the researchers as it was 13 billion years ago. That's the time it took for the galaxy's light to travel to Earth. Just how mind-boggling is that? A single light year, which is the distance light travels in a year, is nearly six trillion miles. Because the universe has been expanding the whole time, the researchers estimate the galaxy's present distance to be roughly 30 billion light years away.

"Because of its distance we get a glimpse of conditions when the universe was only about 700 million years old—only 5 percent of its

current age of 13.8 billion years," said Papovich, an associate professor in the Department of Physics and Astronomy and a member of the George P. and Cynthia Woods Mitchell Institute for Fundamental Physics and Astronomy since 2008.

Papovich notes that researchers are able to accurately gauge the distances of galaxies by measuring a feature from the ubiquitous element hydrogen called the Lyman alpha transition, which emits brightly in distant galaxies. It's detected in nearly all galaxies that are seen from a time more than one billion years from the Big Bang, but getting closer than that, the hydrogen emission line, for some reason, becomes increasingly difficult to see.

"We were thrilled to see this galaxy," Finkelstein said. "And then our next thought was, 'Why did we not see anything else? We're using the best instrument on the best telescope with the best galaxy sample. We had the best weather—it was gorgeous. And still, we only saw this emission line from one of our sample of 43 observed galaxies, when we expected to see around six. What's going on?'"

The researchers suspect they may have zeroed in on the era when the universe made its transition from an opaque state in which most of the hydrogen is neutral to a translucent state in which most of the hydrogen is ionized. So it's not necessarily that the distant galaxies aren't there. It could be that they're hidden from detection behind a wall of neutral hydrogen fog, which blocks the hydrogen emission signal.

Tilvi notes this is one of two major changes in the fundamental essence of the universe since its beginning—the other being a transition from a plasma state to a neutral state. He is leading the effort on a follow-up paper that will use a sophisticated statistical analysis to explore that transition further.

This is an artist's rendition of the newly discovered most distant galaxy z8_GND_5296. (The galaxy looks red in the actual Hubble Space Telescope image because the collective blue light from stars get shifted toward redder colors due to the expansion of the universe and its large distance from Earth.) Credit: V. Tilvi, S.L. Finkelstein, C. Papovich, NASA, ESA, A. Aloisi, The Hubble Heritage, HST, STScI, and AURA.

"Everything seems to have changed since then," Tilvi said. "If it was neutral everywhere today, the night sky that we see wouldn't be as beautiful. What I'm working on is studying exactly why and exactly where this happened. Was this transition sudden, or was it gradual?"

The *Nature* paper is the result of raw data gleaned from a powerful Hubble Space Telescope imaging survey of the distant universe called CANDELS, or Cosmic Assembly Near-Infrared Deep Extragalactic Legacy Survey. Using that data, the team was armed with 43 potential distant galaxies and set out to confirm their distances.

On a crisp, clear April night, Tilvi, Finkelstein and his graduate student, Mimi Song, sat behind a panel of computers in the control room of the W.M. Keck Observatory, which is perched atop the summit of Hawaii's dormant Mauna Kea volcano and houses the two largest optical and infrared telescopes in the world, each standing eight stories tall, weighing 300 tons and equipped with 10-meter-wide mirrors.

They detected only one galaxy during their two nights of observation at Keck, but it turned out to be the most distant ever confirmed. It was at a redshift 7.51—or created about 13 billion years ago. Because the universe is expanding, the space between galaxies also is increasing. And as objects move away, they become redder. In essence, the higher the redshift, the farther away the object. Only five other galaxies have ever been confirmed to have a redshift greater than 7, with the previous high being 7.215.

Finkelstein credits technological advancements in recent years for allowing astronomers to probe deeper into space and closer to the Big Bang. For instance, a powerful new spectrometer called MOSFIRE (Multi-Object Spectrometer For Infra-Red Exploration) that is 25 times more light-sensitive than others of its kind was installed at Keck in 2012. And the Hubble Space Telescope is powered by a new near-infrared camera installed by astronauts aboard the Space Shuttle in 2009 that sees farther into the universe.

Finkelstein and Papovich's collaboration to study distant galaxies and our cosmic evolution is one of several between Texas' two public research

giants in the realm of astronomy. Texas A&M, the University of Texas at Austin and other institutions are building the largest spectrograph in the world to be installed at the Hobby-Eberly Telescope in west Texas to shed light on the mysterious force dark energy that likely is driving the expansion of the universe.

Perhaps the largest and most important collaboration between the two universities' astronomy programs is on the Giant Magellan Telescope, which, when complete in 2020, will create images 10 times sharper than the Hubble Space Telescope and enable astronomers to see earlier into the universe than ever before. Texas A&M and the University of Texas at Austin are two of 10 international institutions that are founding partners on the project.

"The Giant Magellan Telescope will revolutionize this research," Papovich said. "We are pushing the current telescopes to their limits and only seeing the brightest galaxies at these redshifts. It is slow-going with current telescopes. The GMT will have about five times the light gathering power of the biggest telescopes we're using now, and it will make the measurements we're doing that much easier. It will probably take the GMT to really understand the conditions in the very early universe."

Nicholas Suntzeff, director of the Texas A&M astronomy program, said the University of Texas at Austin has been instrumental in helping to boost the College Station program's international profile and providing access to telescopes and facilities. Suntzeff, who this year was appointed Texas A&M's highest faculty rank, distinguished professor, himself serves as an adjunct professor at the University of Texas at Austin.

"If we want to maintain Texas as one of the most important centers in the world for astronomy, we can no longer do it as individual universities," Suntzeff said. "UT, Texas A&M and other universities

must work together. Just as a strength of the University of California program is that its system is united, if we are going to be part of the biggest projects in the world, we must unite our forces. This is the only way we can rejoin the group of elite astronomical institutions that are doing the best science on the biggest telescopes. In Texas, we are on that path."

More information: Paper: dx.doi.org/10.1038/nature12657

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