Hubble Space Telescope spies galaxy 32 billion light years away

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This is a photo of the Hubble Space Telescope. Credit: NASA

When a team of astronomers found a galaxy in the direction of Ursa Major two years ago, they weren't sure what to make of it.

GN-z11, as they named it, seemed small, reddish and unexpectedly bright. It appeared far away even by cosmic standards. But because it was beyond the optimal reach of NASA's Hubble Space Telescope, it left them puzzled.

Now they're certain it represents history.

The international team, which includes an astronomer based in Baltimore, pushed Hubble to its limits this year to demonstrate that GN-z11 is the most distant galaxy ever observed.

"The light that left this galaxy that we're observing now left the galaxy 13.4 billion years ago," said Gabriel Brammer, an astronomer at the Space Telescope Science Institute in Baltimore and the study's second author. "As far as we know, the universe itself is about 13.8 billion years old. We're seeing a galaxy as it was when the universe was about 3 percent of its current age."

The light from GN-z11 is 200 million years closer to the Big Bang than that of the previous record-holder, a galaxy called EGSY8p7 that was found last year. That puts GN-z11 about 32 billion light years away.

Because expansion of the universe over billions of years makes distance calculation complex, astronomers generally represent distance as a function of time -how long it takes light rays originating at a given object to reach us.

Another way they express distance is through a unit of measurement called redshift. The farther away an object, the longer - and therefore redder - the light wavelengths are when they reach us.

The spectroscopic redshift of EBSY8p7 was measured at a sizable 8.8, then believed to be at or beyond the outer edge of Hubble's range. GN-z11 has a redshift of 11.1, such a big jump that few saw it coming.

The findings - described in a recent article in The *Astrophysical Journal* - give scientists what appears to be their best view yet of conditions near the end of the so-called Dark Ages of the Universe, when the cosmos was still opaque and just before the first stars and quasars formed.

"We've taken a major step back in time, beyond what we'd ever expected to be able to do with Hubble," said Pascal Oesch, a Yale University astronomer and the study's principal investigator.

Oesch and his team discovered GN-z11 in 2014 during a routine survey of a small patch of sky.

In addition to taking note of the galaxy, they used imaging from both the orbiting Hubble - the most powerful telescope in history - and NASA's Spitzer Space Telescope, an infrared instrument in Pasadena, Calif., to ascertain its color to estimate its distance.

They came up with an estimated redshift of 10.2, which in itself would have been a record for Hubble, but the image came with enough visual interference, or "noise," that the number had a sizable margin of error.

Also, Brammer said, team members couldn't be sure they weren't seeing an "interloper" - a much closer object - by mistake.

But the galaxy's unusual brightness gave investigators a lucky second option: to use a more exacting measurement method known as spectroscopy - a way of splitting the visible light into its component colors - to firm up the distance estimate.

Analyzed with this method, GN-z11 registered the record redshift of 11.1 - and it exhibited many of the clear properties of an infant galaxy, not an interloper.

For one thing, the team found, even though it's only 0.04 percent the size of our Milky Way galaxy, GN-z11 appears to be forming stars at a staggering rate, about three times more rapidly than expected and 20 times more quickly than the Milky Way.

That, they say, is why it's so much more luminous than many models predicted.

"Our earlier work had suggested that such bright galaxies should not exist so early in the universe," Marijn Franx, a team member from the University of Leiden in the Netherlands, told Astronomy Magazine.

"What we're seeing is young stars, massive stars, stars just being formed. At first glance, this galaxy appeared to be red, but that was because it's so far away. On closer look, it's actually very blue," Oesch said.

Hubble has amassed hundreds of images of galaxies in the range of redshift 7 or 8 in its 26-year existence, Brammer said, allowing astronomers to develop a relatively clear picture of those galaxies' general properties - their star formation rates, their chemical makeup, their brightness - at those times and distances.

That has helped scientists create a fuller, more credible map of how the universe evolved back to about half a billion years after the Big Bang.

It's harder to extrapolate such a clear picture from a single example of a redshift higher than 11, but astronomers say it's still striking to see evidence that at least one galaxy was up, running and fully active so much earlier than many previously believed.

Astronomers believed there had to be a sizable time gap between the Big Bang and the eras in which the first stars took shape, forming the groups that would become galaxies, Oesch said.

The team's work suggests the gap is smaller and the primordial population more active.

Some in the field remain skeptical of the findings.

Astronomer Richard Ellis of the European Southern Observatory said in an email that the luminosity the group claims is three times higher than that of similar bodies "at much later times," and that astronomers seeking to measure distances greater than redshift 10 usually do so in conjunction with powerful ground-based telescopes such as the ones at the W.M. Keck Observatory in Hawaii.

Ellis said, "The ultimate proof can only come from a higher resolution spectrum such as those published for previous record-holders, either via a long integration with a ground-based telescope or, shortly, with the James Webb Space Telescope" - the Hubble's more powerful successor, which is now under construction and expected to be launched in 2018.

Everyone agrees that the Hubble has looked as far off in the universe as it's going to, given the size of its primary mirror (2.4 meters in diameter) and other limitations.

The Space Telescope Science Institute, which calibrates Hubble's instruments and interprets its raw data, is well along in the process of helping NASA build the Webb telescope, with a 6.5-meter mirror.

Astronomers say Hubble's recent feats suggest the Webb will routinely be able to look farther, providing better answers to what Oesch calls "the very, very big" questions.

"Where do these galaxies come from? Where did we all come from? Where did everything start?" he asked. "That's what we're really asking. We're getting closer all the time."

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