Images hint at seeds of a giant galaxy

This could be the start of something big.

Peering far back in cosmic time, the Hubble Space Telescope has spied a group of 18 diminutive youngsters that may represent the building blocks of a giant galaxy like the Milky Way. Huddled together, these starry bodies appear poised to merge and, over time, to form one or two large galaxies, says Rogier A. Windhorst of Arizona State University in Tempe.

Indeed, four of the objects have double centers, indicating that they have already coalesced with a neighbor.

If Windhorst and his colleagues are right, the Hubble image has captured the pieces of a galaxy before they had assembled, providing a striking illustration of the bottom-up theory of galaxy formation, in which large galaxies arise from the merger of smaller objects. Although astronomers have found many tiny, compact galaxies still in their first blush of youth (SN: 2/24/96, p. 120), Windhorst notes that no one has ever seen so many of these objects bunched together in a patch of sky as small as 2 million light-years across.

The Hubble observations suggest, but don't prove, that the 18 objects, each about one-fiftieth the diameter of the Milky Way, all lie at the same distance from Earth. Ten of them certainly do: Observations with ground-based telescopes place them about 11 billion light-years away. This indicates that Hubble has provided a snapshot of how these objects looked when the universe was 11 billion years younger, or 10 to 20 percent of its current age.

If these youngsters are seen as they were about to assemble into a single large galaxy, the images would also uphold the cold dark matter theory of galaxy formation. This theory, which is consistent with the bottom-up theory, holds that invisible, slow-moving particles make up most of the universe and that giant galaxies can't form earlier than a billion or so years after the birth of the universe. That timing dovetails with Hubble's observation of these 18 bodies, Windhorst and his collaborators assert in the Sept. 5 NATURE.

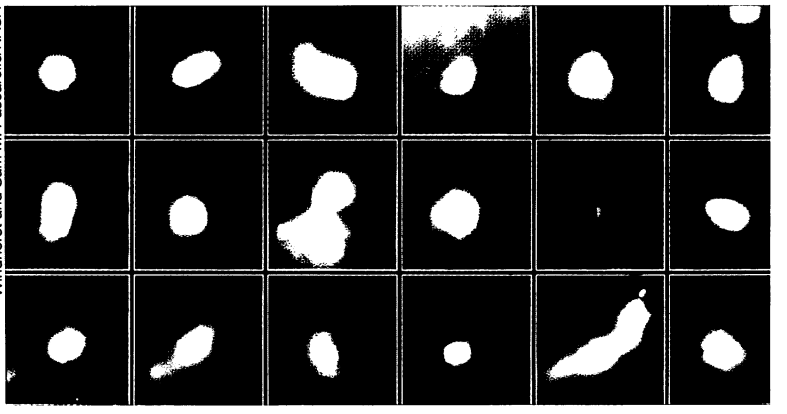
Another interpretation of the findings refutes the merger notion and might sound the death knell for cold dark matter in its standard form.

Several astronomers, including Judith G. Cohen of the California Institute of Technology in Pasadena and Mark Dickinson of the Space Telescope Science Institute in Baltimore, suggest that the objects discovered by Windhorst's team aren't fragments of a giant galaxy-to-be but bona fide galaxies in their own right. The grouping would then constitute a young cluster whose galaxies had formed much too early for the cold dark matter model to explain.

Cohen notes that without further data, it's impossible to determine whether the 18 objects were about to coalesce or just remain clustered. She notes that researchers have found hints of galaxy clustering even further back in time and that her own studies show clustering at a time when the universe was about half its present age (SN: 6/29/96, p. 406). Cohen adds that if the objects do serve as building blocks, then the cosmos must have contained many more galactic objects in the distant past than it does today, a finding that may not square with the counts of galaxies at different epochs of the cosmos.

Windhorst says that if surveys of adjacent areas of sky were to add more objects to his grouping, then he, too, would favor the clustering hypothesis. He comments that if the 18 objects, which glow with the blue light of young stars, are common in other parts of the sky, they could account for the excess of faint blue objects seen at great distances.— *R. Cowen*

Windhorst and Sam M. Pascarelle/NASA



Hubble image shows 18 small bodies, each containing about a billion stars, that may build a large galaxy.

Results from a solar cycle of neutrino data

Since it began watching the sun in 1987, Japan's Kamiokande neutrino detector has provided data important for understanding how nuclear fusion reactions power the sun and for testing theories of stellar evolution. Fusion reactions in the sun's core produce huge quantities of neutrinos, elusive subatomic particles that interact weakly with ordinary matter. Earth-based detectors pick up only a tiny fraction of these particles.

By the time it was shut down last year to make way for a considerably more sensitive experiment, the original Kamiokande detector had accumulated data covering nearly a complete solar cycle, the roughly 11-year period during which sunspot activity goes from a minimum to a maximum and back to a minimum.

Earlier studies, based on data from a different solar neutrino detector, had hinted at a correlation between the number of neutrinos arriving at a collector and solar activity, with the detection rate decreasing as the number of sunspots increases (SN: 12/8/90, p. 358). If such a connection had been confirmed, it would have provided evidence that the neutrino has a mass and could change from one type of neutrino to another (SN: 5/18/96, p. 319).

In their final report, however, members of the Kamiokande collaboration conclude that they observed no month-to-month or year-to-year variations in the number of neutrinos detected that would match the pattern of solar activity throughout this period.

"No strong correlation of the solar neutrino flux with the sunspot numbers was found within experimental [uncertainties]," Yoshiyuki Fukuda of the Institute for Cosmic Ray Research at the University of Tokyo and the other members of the Kamiokande collaboration report in the Aug. 26 PHYSICAL REVIEW LETTERS.

Located in a mine about 200 kilometers west of Tokyo and a kilometer underground, to shield it from less penetrating rays, the Kamiokande detector consisted of a cylindrical tank containing 3,000 tons of pure water. Sensitive photodetectors lining the tank's walls picked up light flashes generated by speeding electrons knocked aside on the rare occasions—averaging less than once a day—when neutrinos interacted with water.

The detector was the first to show directly that the observed neutrinos came from the direction of the sun rather than from other possible sources (SN: 10/28/89, p. 280). The energy of the neutrinos indicated that they originated in the decay of boron-8, an isotope created near the end of the chain of nuclear fusion reactions fueling the sun.

Kamiokande's detection rate of boron-8 neutrinos was about half that predicted by theorists calculating the sun's output using the standard solar model. Other experiments have found a similar, persistent shortfall, suggesting either that models of the sun's interior are incomplete or that neutrino physics may be more complicated than expected.

The Super Kamiokande detector, which replaces the original Kamiokande, started up April 1. It is expected to detect about 100 times as many neutrinos per day as its predecessor. — *I. Peterson*