UMass Amherst astronomers' camera leads to discovery of early galaxies

January 13 2011

An international team of astronomers including Grant Wilson and Min Yun at the University of Massachusetts Amherst has detected one of the earliest "protoclusters" of galaxies ever identified, located about 12.5 billion light years from Earth. Wilson and Yun are part of a group led by Peter Capak of the California Institute of Technology. Their findings appear in the current issue of *Nature*.

The protocluster of very early galaxies is centered on a source dubbed AzTEC 3, after the millimeter-wave instrument that first saw it. The full collection of galaxies, called the COSMOS-AzTEC protocluster, has been caught in the act of formation when the universe was only 1 billion years old.

Wilson says the observation is surprising because current theory suggests finding such a nascent congregation or cluster of galaxies in the early stages of formation should be very difficult. "Clusters, which are some of the biggest structures in the universe, are relatively rare. If galaxies spread through the universe are like towns dotting the Earth, fully grown clusters would be like the biggest cities," he notes.

He likens discovery of the COSMOS-AzTEC protocluster to peering at the first houses on Manhattan Island, destined to be among the most populous places on the planet. Because light from such distant objects takes so long to reach Earth, astronomers are essentially looking back in time at the early days of an object which someday will be one of the most massive in the universe.

AzTEC 3 was one of the very first objects discovered by the team using the AzTEC camera and one of the first few AzTEC galaxies to be followed up with detailed scrutiny by other telescopes.

What are the chances of detecting something as important and rare as one of the earliest-known protoclusters in the universe on the first try? As Wilson sees it, "We either got extremely lucky, or the universe biased our search and provided a signpost, like the tip of an iceberg sticking up out of the sea, that attracted our attention. Because they are monstrously huge and unusual, I think it may not be so crazy to think that galaxies like AzTEC 3 tend to exist in special places in the universe and we just don't understand the signpost yet. That's one thing we'll definitely be looking to explain in the future."

Most astronomers believe that such a massive cluster should not be mature until 2 to 3 billion years later, Wilson's UMass Amherst colleague Yun explains. "Such a young cluster is really interesting. The current computer simulations of the universe suggest that we were extremely fortunate to find it."

The astronomers focused their hunt for a protocluster at the location of one of the first galaxies discovered by the AzTEC camera. "AzTEC 3, at the heart of the cluster is a fairly rare, and really massive, type of galaxy called a starburst--an incredibly prolific producer of new stars. Judging by the brightness of its millimeter-wave signature, AzTEC 3 must be producing about 1,000 new stars every year, compared to the one to three new stars produced by the Milky Way annually," Wilson points out.

In addition to AzTEC 3, the COSMOS-AzTEC protocluster also contains a super massive black hole and several other interesting galaxies. "It's a real collection of odd and intriguing sources, all congregating when the universe was in its infancy," says Yun.

At UMass Amherst, Wilson led a team of international astronomers who designed and built AzTEC, the special millimeter wave-detecting camera, which is about the size and shape of a 55-gallon drum. It can collect images of thermal radiation emitted from distant galaxies that are filled with dust created by the formation and death of stars.

Some galaxies, such as AzTEC 3, have so much dust that most of the light they emit is trapped, unable to penetrate the cocoon of dust surrounding them. This makes them nearly invisible even to the most powerful optical instruments such as the Hubble Space Telescope. The active formation of stars heats this dust which then glows like embers in a fireplace. AzTEC is able to take pictures of that glow. "We call this star formation starbursting because it's thought to be a rather violent and short-lived phase, about 50 million years, in the galaxy's life," Wilson says.

Capak, Wilson and colleagues first used the AzTEC camera to identify candidate dusty starburst galaxies, and then followed up with observations at the Submillimeter Telescope Array and the Keck 10-meter optical telescopes on Mauna Kea, Hawaii, to measure the galaxies' emission lines, or red shift. This measure yields the age of the universe at the time the galaxies emitted their light, in this case estimated at 1 billion years.

AzTEC, the UMass Amherst instrument, was funded in part by the National Science Foundation. It will be installed at the Large Millimeter Telescope, a 50-meter millimeter-wavelength telescope in Mexico expected to be completed in mid-2011.

Provided by University of Massachusetts Amherst