Chile's ALMA probes for origins of universe

October 26 2012, by Luis Andres Henao

In this Sept. 27, 2012 photo, radio antennas face the sky as part of one of the worlds largest astronomy projects, the Atacama Large Millimeter/submillimeter Array (ALMA) in Chajnator in the Atacama desert in northern Chile. Linked as a single giant telescope, the radio antennas pick up wavelengths of light longer than anything visible to the human eye and colder than infrared telescopes, which are good at capturing images of distant suns but miss planets and clouds of gases from which stars are formed. (AP Photo/Jorge Saenz)

(AP)—Earth's largest radio telescope is growing more powerful by the day on this remote plateau high above Chile's Atacama desert, where

visitors often feel like they're planting the first human footprints on the red crust of Mars.

The 16,400-foot (5,000-meter) altitude, thin air and mercurial climate here can be unbearable. Visitors must breathe oxygen from a tank just to keep from fainting. Winds reach 62 mph (100 km) and temperatures drop to 10 below zero (minus 25 Celsius).

But for astronomers, it's paradise.

The lack of humidity, low interference from other radio signals and closeness to the upper atmosphere make this the perfect spot for the Atacama Large Millimeter/submillimeter Array, or ALMA, which is on track to be completed in March.

So far, 43 of the 66 radio antennas have been set up and point skyward like 100-ton white mushrooms. Linked as a single giant telescope, they pick up wavelengths of light longer than anything visible to the human eye, and combine the signals in a process called interferometry, which gives ALMA a diameter of 9.9 miles (16 kilometers). The result is unprecedented resolution and sensitivity—fully assembled, its vision will be up to ten times sharper than NASA's Hubble Space Telescope.

"What surprises me is what is being observed. Until now, we haven't had such a capable observatory. We've never been able to observe with such resolution, such accuracy," says David Rabanus, ALMA's instrument group manager.

More than 900 teams of astronomers competed last year to be among the first to use the array, and scientists from around the world are already taking turns at the joysticks.

They're looking for clues about the dawn of the cosmos—from the

coldest gases and dust where galaxies are formed and stars are born, to the energy produced by the Big Bang. So-called birthing clouds of cold gases and debris can look like ink stains with other telescopes, but ALMA can show their detailed structures.

ALMA also reaches farther beyond Earth's nitrogen-blue skies than any other radio telescope and has already captured images different from anything seen before by visible-light and infrared telescopes. After a 2003 groundbreaking, scientific operations began last year with a quarter of ALMA's final capacity.

Seeing in three dimensions made possible the recent discovery of a spiral structure surrounding R Sculptoris, providing new insights about how dying red giant stars implode and send off raw material that will later form into other stars. Those results were published in the scientific journal Nature. ALMA has even been able to detect sugar molecules in the gas surrounding a star about 400 light years away, proving the existence of life's building blocks there.

In this Sept. 26, 2012 photo, people work on antennas at the European assembly area at one of the worlds largest astronomy projects, the Atacama Large Millimeter/submillimeter Array (ALMA) in the Atacama desert in northern Chile. Linked as a single giant telescope, the radio antennas pick up wavelengths of light longer than anything visible to the human eye and colder than infrared telescopes, which are good at capturing images of distant suns but miss planets and clouds of gases from which stars are formed. (AP Photo/Jorge Saenz)

Jointly funded and managed by the United States, Canada, the European Union, Japan and Taiwan, the $1.5 billion project is an engineering triumph that launches Chile, already home to some of the world's largest optical telescopes, to the forefront of ground-based space exploration.

In this Sept. 26, 2012 photo, the moon shines over radio antennas at the operations support facility of one of the worlds largest astronomy projects, the Atacama Large Millimeter/submillimeter Array (ALMA) in the Atacama desert in northern Chile. Linked as a single giant telescope, the radio antennas pick up wavelengths of light longer than anything visible to the human eye and colder than infrared telescopes, which are good at capturing images of distant suns but miss planets and clouds of gases from which stars are formed. (AP Photo/Jorge Saenz)

"We're talking about the United Nations of astronomy joined for a billion dollar adventure. Scientists are like kids playing with very expensive toys and these ones are technological developments that could change the world," said Jose Maza, a University of Chile astronomy professor.

But this space race isn't over: Australia and South Africa are competing to build The Square Kilometer Array, combining thousands of small

dishes to create a radio telescope 50 times more sensitive than ALMA once completed in 2024.

ALMA's parts are shipped from all over the world and assembled at a warehouse 9,514 feet (2,900 meters) above sea level. The precision is micrometric. The telescope employs reflecting panels that must be aligned and glued so accurately to withstand each winter's subzero temperatures and bounce radio waves within a hundredth of a millimeter's precision.

The dishes are hauled up to their final destination by two custom-made 28-wheel transporters that roar along snaky roads, lined with oversized cactuses and grazing vicunas below the snow-peaked Licancabur volcano. The trip is only 22 miles (35 kilometers), but it takes five hours for the huge platforms to reach the plateau.

Each antenna is perched on a rotating steel pedestal with precisely installed copper lining to protect from lightning. Each dish has a sensitive receiver made of carbon fiber to avoid thermal expansion. The structures, 40 feet (12-meter) tall, lean closer together or farther apart as astronomers zoom in or get wider views. The ALMA correlator, which calculates more than 20 quadrillion operations per second, is the fastest computer ever used at an astronomical site. It compiles the data into a single large view.

"We came from the caves and we're here now just because of curiosity," said Rieks Jager, system integration manager at ALMA, as he stepped out of the control room near the "silent area" military-style barracks where astronomers sleep during the day. "It's not always clear what we study, or whether it's useful for society, but overall it's absolutely essential for humankind."

It's a quantum leap forward since Italian astronomer Galileo Galilei

invented one of the first telescopes in the 17th century, discovering sunspots and valleys on the surface of the moon.

"Astronomy has been with us forever and we still have so much more to go," said Maza, the astronomy professor. "If we hadn't asked ourselves so many questions by looking at the stars we would still be ... hunting buffalos. At the end, all of man's development comes from the act of leaving the stones aside and looking upward at the twinkling stars and asking, 'Why?' "

ALMA reminds Juan Rodrigo Cortes, one of the observatory's astronomers, of a phrase from Antoine De Saint Exupery's book "The Little Prince"—"What is essential is invisible to the eyes."

"What's essential here is the material that creates stars, galaxies, clouds, that doesn't emit light visible to our eyes, but goes way beyond the infrared at much longer wavelengths, and that's why our eyes can't see it," Cortes said. "ALMA gives us eyes."

Scientists and researchers are willing to go to extremes to catch a glimpse of the universe through those eyes.

As many as 500 people at a time live at 9,500 feet above sea level in shipping containers modified as trailers. Alcohol is banned due to the sensitivity of the equipment, and those caught drinking after trips to the nearby city of San Pedro de Atacama must sleep at the security checkpoint while they dry out. Their shifts can last 12 hours daily for eight straight days.

Even the weather is unpredictable. Although the clearest of skies are the norm, this year, scientists have had to deal with mudslides, floods and thunderstorms. But most of the time, they seem to be far removed from the rest of the world.

Inside ALMA's control room, German astronomer Rainer Mauersberger had no idea he had put his orange sweater on backward. He was thinking about the formation of galaxies, hoping perhaps to spot a black hole.

"This project has to do with the origin of our life and our future," Mauersberger explained as he sat near a long table full of Halloween masks, used by the scientists to share a light moment or a laugh to break up the long days and nights of stargazing.

"It's about how can we predict our future climates, the evolution of the earth, the sun, our species," he said. "We know more about our universe, our culture, than we ever dreamt of 100 years ago. Our prediction is that the real surprises here will come with things that we can't even begin to imagine."