The Atacama Large Millimeter/submillimeter Array — In Search of Our Cosmic Origins

European Southern Observatory

The Southern Milky Way Above ALMA. Credit: ESO/B. Tafreshi (twanight.org)

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High on the Chajnantor Plateau in the Chilean Andes, the European Southern Observatory (ESO), together with its international partners, is building and operating the most complex ground-based astronomical project in existence. The Atacama Large Millimeter/submillimeter Array, ALMA, is a state-of-the-art, revolutionary telescope which captures light from some of the coldest objects in the Universe. This light has a typical wavelength of around a millimetre, lying between infrared radiation and radio waves in the electromagnetic spectrum, and is therefore known as millimetre and submillimetre radiation. ALMA is composed of 66 high-precision antennas, operating at wavelengths of 0.32 to 3.6 millimetres.

Light at these wavelengths comes from vast cold clouds in interstellar space, at temperatures only a few tens of degrees above absolute zero, and from some of the earliest and most distant galaxies in the Universe. Astronomers can use this light to study the chemistry of molecules in interstellar clouds, and the physics and chemistry of how stars and planetary systems are born. Often these cold, dense regions of the Universe are dark and obscured in visible light, but they shine brightly in the millimetre and submillimetre part of the spectrum.

Millimetre and submillimetre radiation opens a window into the enigmatic cold Universe, but the signals from space are heavily absorbed by water vapour and oxygen in the Earth's atmosphere. Telescopes for this kind of astronomy must be built on high, dry sites.

The plateau at Chajnantor, at 5000 metres above sea level, and some 50 kilometres east of San Pedro de Atacama in northern Chile, is one of the driest places and highest astronomical observatory sites on Earth. This is why Chajnantor was selected as the home of ALMA. Astronomers find unsurpassed conditions for observing here, but they must operate a frontier observatory under very difficult conditions. Chajnantor is more than 750 metres higher than the observatories on Mauna Kea, and 2400 metres higher than the Very Large Telescope (VLT) on Cerro Paranal.

ALMA's main array has fifty antennas, each 12 metres in diameter, acting together as a single telescope — an interferometer. An additional compact array of four 12-metre and twelve 7-metre antennas complements this. The 66 ALMA antennas can be arranged in different configurations, where the maximum distance between antennas can vary from 150 metres to 16 kilometres, which gives ALMA a powerful variable "zoom". It probes the Universe at millimetre and submillimetre wavelengths with unprecedented sensitivity and resolution, with a vision up to ten times sharper than the Hubble Space Telescope, and complementing images made with the VLT Interferometer.

ALMA is the most powerful telescope for observing the cool Universe — molecular gas and dust as well as the relic radiation of the Big Bang. ALMA studies the building blocks of stars, planetary systems, galaxies, and life itself. By providing scientists with detailed images of stars and planets being born in gas clouds near the Solar System, and detecting distant galaxies forming at the edge of the observable Universe, which we see as they were roughly ten billion years ago, it lets astronomers address some of the deepest questions of our cosmic origins.

ALMA's construction is nearing completion, and early scientific observations with a partial array began in 2011.

The ALMA project is a partnership of Europe, North America and East Asia in cooperation with the Republic of Chile.

ALMA is funded in Europe by the European Southern Observatory (ESO), in North America by the U.S. National Science Foundation (NSF) in cooperation with the National Research Council of Canada (NRC) and the National Science Council of Taiwan (NSC) and in East Asia by the National Institutes of Natural Sciences (NINS) of Japan in cooperation with the Academia Sinica (AS) in Taiwan. ALMA construction and operations are led on behalf of Europe by ESO, on behalf of North America by the National Radio Astronomy Observatory (NRAO), which is managed by Associated Universities, Inc. (AUI) and on behalf of East Asia by the National Astronomical Observatory of Japan (NAOJ). The Joint ALMA Observatory (JAO) provides the unified leadership and management of the construction, commissioning and operation of ALMA.

www.eso.org/alma
www.almaobservatory.org/

ALMA (ESO/NAOJ/NRAO), Visible light image: the NASA/ESA Hubble Space Telescope

ALMA and Hubble observations of the Antennae Galaxies.

About ESO

ESO, the European Southern Observatory, is the foremost intergovernmental astronomy organisation in Europe. It is supported by 15 countries: Austria, Belgium, Brazil*, the Czech Republic, Denmark, France, Finland, Germany, Italy, the Netherlands, Portugal, Spain, Sweden, Switzerland and the United Kingdom.

ESO carries out an ambitious programme focused on the design, construction and operation of powerful ground-based observing facilities enabling astronomers to make important scientific discoveries. ESO plays also a leading role in promoting and organising cooperation in astronomical research. ESO operates facilities at three unique world-class observing sites in the Atacama Desert region of Chile: La Silla, Paranal and Chajnantor.

* Brazil is in the process of ratifying its membership in the Brazilian parliament.

ESO
education and Public Outreach Department
Karl-Schwarzschild-Straße 2
85748 Garching bei München
Germany

Tel. +49 89 320 060
Fax +49 89 320 2362
E-mail information@eso.org
www.eso.org