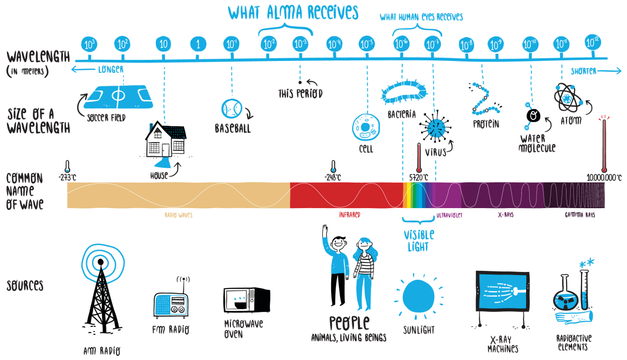
ELECTROMAGNETIC SPECTRUM

The Sun emits light. Although it looks white, the light of the Sun is made up of several colors, like those seen in a rainbow. Each color has its own wavelength, and the red wavelengths are longer than the violet ones.

But there are more colors than those we can see in a rainbow. In fact, scientists have discovered several types of invisible light. Infrared light, for example (or "hot radiation"), can't be seen by people, but it can be seen by snakes. Ultraviolet light (the light that gives us a suntan), which we also can't see, is visible to bees.

Together, all the forms of existing light (or radiation) make up the electromagnetic spectrum, which ranges from extremely long radio waves to ultrashort gamma rays. What we call visible light is only a tiny part of the existing light. Each one contributes in its own unique way to the understanding of the Universe.

The electromagnetic spectrum can be seen in the middle of the image below. Above it, we can see the wavelengths, and below, there are examples of objects and instruments that emit the different types of radiation.

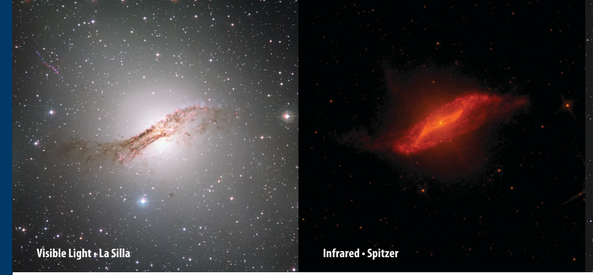


The Atacama Large Millimeter/submillimeter Array (ALMA), an international astronomy facility, is a partnership of the European Organisation for Astronomical Research in the Southern Hemisphere (ESO), the U.S. National Science Foundation (NSF) and the National Institutes of Natural Sciences (NINS) of Japan in cooperation with the Republic of Chile. ALMA is funded by ESO on behalf of its Member States, by NSF in cooperation with the National Research Council of Canada (NRC) and the Ministry of Science and Technology (MOST) and by NINS in cooperation with the Academia Sinica (AS) in Taiwan and the Korea Astronomy and Space Science Institute (KASI).

ALMA construction and operations are led by ESO on behalf of its Member States; by the National Radio Astronomy Observatory (NRAO), managed by Associated Universities, Inc. (AUI), on behalf of North America; and by the National Astronomical Observatory of Japan (NAOJ) on behalf of East Asia. The Joint ALMA Observatory (JAO) provides the unified leadership and management of the construction, commissioning, and operation of ALMA.

Exploring Our Cosmic Origins

www.almaobservatory.org

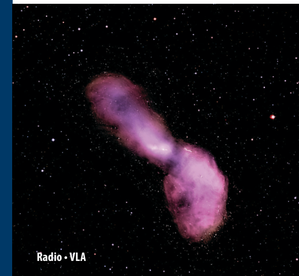


Visible Light • La Silla

Infrared • Spitzer

Visible Light & Mm/submm • ALMA

WITH WHAT EYES DO YOU OBSERVE THE UNIVERSE?



Radio • VLA

X Rays, Radio Waves & Visible Light

X Rays • Chandra

WELCOME TO THE UNIVERSE OF ALMA

TIMELINE

2003: Start of construction.

2007: Arrival of the first antenna to Chile.

2008: Arrival of the two ALMA transporters.

2009: May – First antenna synchronization.
September – First antenna at Chajnantor (5,000 m altitude).

2011: First Scientific observations with 16 antennas.

2012: First results – ALMA confirms the existence of small planetary growth from dust star.

2013: ALMA inauguration with the arrival of antenna number 66.

2014: First observations in extended antenna configuration, delivering the best image to date of a protoplanetary disk.

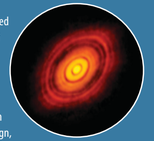
2019: First image of a *black hole* published by the Event Horizon Telescope consortium, for which ALMA is one of the fundamental instruments.

ALMA is the Atacama Large Millimeter/submillimeter Array

- Chajnantor Plateau, 5,000 meters above sea level
- Atacama Desert, Chile
- 66 antennas forming one single telescope
- A global partnership between Europe, North America, East Asia and Chile.

Credit: Guy Wenborne

WHAT IS ALMA?



The most powerful Earth-based observatory in the history of humanity is located at an altitude of 5,000 meters in the Atacama Desert. It is so large and complex that it required a partnership of scientists and engineers from all around the world for its design, construction and operation. This global collaboration is opening the door to unexplored frontiers. With 66 antennas, which are 12 meters and 7 meters in diameter, designed to observe millimetric and submillimetric wavelengths, ALMA is revolutionizing modern astronomy by enabling us to view how the first galaxies in the Universe were created and to obtain extremely detailed images of stars and planets as they are forming.

WHAT IS A RADIO TELESCOPE?

Unlike optical telescopes such as the one built by Galileo Galilei more than 400 years ago, which captures only images from the visible light spectrum, radio telescopes are designed to capture radio waves emitted by cold or very distant sources in space. A very large surface for data collection is needed to capture the weakest signals of this cold or distant Universe (just after the Big Bang). As it is impossible to build a single giant telescope, this requires multiple parabolic antennas that can work together like one large telescope. This technique, known as interferometry, enables ALMA to function as a single virtual telescope with a 16-kilometer diameter!

WHY SO HIGH? WHY SO DRY?

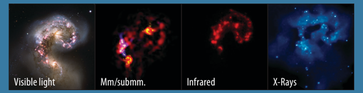
The principal enemy of radio astronomy and of ALMA is humidity, because water vapor present in the atmosphere distorts signals from space. To avoid this, it was necessary to place the antennas in the highest, driest place possible. After many years of searching, scientists determined that the Chajnantor plateau, at an altitude of more than 5,000 meters in the Atacama Desert, is the best location.

Also, it had to be a very flat location so that the 66 ALMA antennas could form different configurations with minimal altitude difference between them. Finally, the location needed to be accessible to bring the antennas and operate a telescope of this size.

Chajnantor Plateau – 5,000 m

HOW DOES ALMA SEE?

For four centuries, telescopes of all kinds have been treating us to views of the Universe that intrigue and astound us. With ALMA, we are able to contemplate, in vivid clarity, what no optical telescope has ever seen. All these sectors of the Universe that seemed empty and uninteresting are now being illuminated for us with an unprecedented clarity.



The same image viewed with different telescopes

SO MANY ANTENNAS!

The millimetric and submillimetric wavelengths that ALMA captures correspond to energy a thousand times weaker than the emissions that our eye can detect. The only way to capture these and obtain a clear image of light with such wavelengths is by building a very large telescope. It must be 500 times wider than the human eye to observe with the same clarity as the human eye in visible light. That's why the largest number possible of antennas must work together like one giant telescope. With its 66 antennas, ALMA is able to obtain details with at least ten times more resolution than the Hubble Space Telescope.

TRANSPORTERS

Depending on what you want to observe, the antennas can be placed closer together (giving ALMA greater sensitivity to observe large spaces in the Universe) or further apart (achieving greater resolution, i.e., the ability to observe more details). To transport them and arrange them in different configurations, ALMA has two giant transporters, named Otto and Lore, which were made just for this purpose. They are incredibly powerful: each one weighs 130 tons, has two 670 horsepower engines and traction on its 28 wheels. They can also be operated by remote control for optimum vision during delicate maneuvers, such as loading and unloading 100-ton antennas with millimetric precision.

WHAT CAN ALMA DISCOVER?

Stars

Stars shine for millions and millions of years, but their formation has remained a mystery, since visible light telescopes are unable to penetrate the nebulae, which are the true "star maternity wards." ALMA is able to peer into these dusty concentrations of molecular gas and dust from which stars are born.

Planets

Today we know that planets form around a new star by condensing into a disk of molecular gas and dust that is embedded within a much larger molecular cloud. The condensation grows to become a giant planet, while the gas that remains in the disk eventually disappears, leaving behind planets and a disk of dust and debris. ALMA studies these unknown phases of planetary formation, plotting these phenomena in high resolution and detecting the light of future planets as they grow.

Molecules

On a microscopic level, space reveals true chemical factories of mind-boggling complexity. Chemical elements link up to form molecules. This process continues and diversifies as molecules are liberated from the dust by warming, becoming gaseous in space. These are the fundamental building blocks of life and fuel young planets. ALMA has an unprecedented ability to discover and measure the presence of molecules and their distribution in space. We are learning about the chemistry of the Universe, irreproducible in laboratories on Earth.

ALMA is a scientific and engineering feat that constitutes an enormous window into the Universe, which surprises us every day with discoveries we hadn't even imagined.