ALMA

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2024 CALENDAR

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Starry ALMA

Welcome to ALMA!

The image captures the majestic Milky Way, with the giant letters representing the Atacama Large Millimeter/submillimeter Array (ALMA) at the Operations Support Facility located 2900 meters above sea level in the Andes Mountains. This facility is vital to the observatory, housing the antenna control room, laboratories, offices and the staff residence. Located just 30 minutes from San Pedro de Atacama in northern Chile, this is where most of the observatory's activities take place.

ALMA operates on land granted by the government of Chile in the Atacama desert, one of the driest places on Earth. This environment, although inhospitable, has been home to ancestral communities, such as the Atacameños or Likan Antai, since ancient times. The Andean vision of the Cosmos, unlike the western one, focuses on the constellations formed by the dark spaces in the night sky; coincidentally the same areas studied by ALMA.

Credit: M. J. López – ALMA (ESO/NAOJ/NRAO)

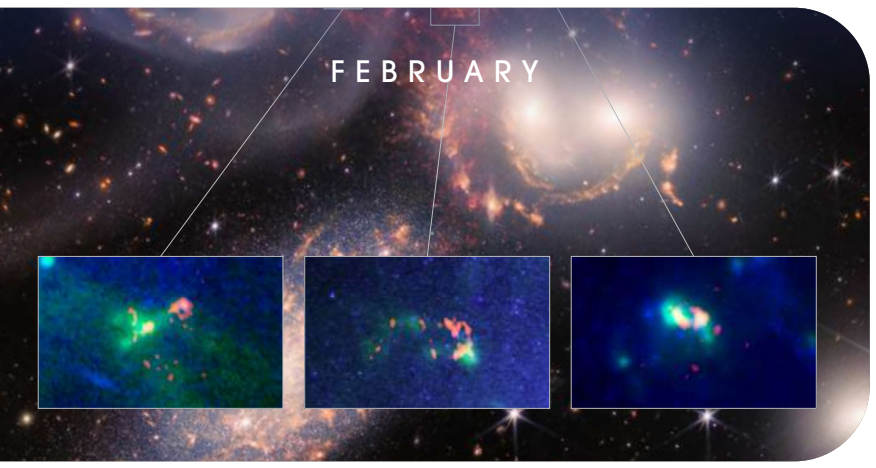
Chajnantor

Chile has built a reputation as a world leader in astronomy, thanks to the exceptional conditions of the Atacama Desert. Its climate and geography guarantee unparalleled clarity, and the high altitude of the Andes Mountains provides a unique environment on Earth. The privileged southern sky makes it possible to observe crucial astronomical objects, such as the center of the Milky Way and the Magellanic Clouds.

These qualities have attracted numerous international collaborations, making Chile home to some of the most advanced observatories in the world. After a global search for a suitable site, the scientific community selected Chajnantor, a plateau with exceptional characteristics in terms of altitude, size and climate, ideal for ALMA.

However, the scientific community was not the first to recognize Chajnantor's uniqueness. The name, which in the Kunza language of the Atacameños, or Likan Antai, means "take-off site", reflects the deep connection of these indigenous people with the sky.

Credit: J. Rojas – ALMA (ESO/NAOJ/NRAO)



ALMA and James Webb reveal impact of a galaxy collision

Using observations from ALMA and the James Webb Space Telescope, the impact of a galaxy collision was revealed in Stephan's Quintet, a group of five galaxies located 270 million light-years away in the Pegasus constellation. This event triggered shockwaves that kickstarted a recycling plant for warm and cold molecular hydrogen gas, revealing unusual phenomena in the intergalactic medium. Astronomers also found a giant cloud of cold gas breaking apart into a plume of hot hydrogen, as well as the collision of two gas clouds that left a tail of warm gas and the possible formation of a new galaxy. These discoveries are key to understanding how turbulence affects gas in space and provide a unique glimpse into star formation processes under unusual conditions.

Credit: ALMA (ESO/NAOJ/NRAO)/JWST/ P. Appleton (Caltech), B.Saxton (NRAO/AUI/NSF)

Sensitivity taken to the extreme

ALMA staff photographed with a fisheye lens in the receiver cabin of an antenna. To capture the cold Universe, ALMA has sophisticated receivers that must operate at extremely low temperatures (-269 degrees). This freezes or reduces the "thermal noise" to capture the weak signals from the Cosmos.

The ALMA signal reception, conversion, processing and recording system is part of a complex chain. This begins in the Front End, which detects astronomical signals at ten different frequency bands. This system is far superior to any other in existence. In fact, products derived from ALMA prototypes are improving the sensitivities of other radio telescopes around the world. The Front End units are composed of numerous elements that are produced as far away as Europe, North America, East Asia and Chile.

Credit: J. Rojas – ALMA (ESO/NAOJ/NRAO)

Dancing with black holes

Using ALMA, an international research team delved into NGC 1068 (M77), a supermassive black hole located 51.4 million light-years from Earth in the Cetus constellation, revealing how it alters molecular gas and impacts star formation. The study, which highlights the interaction of bipolar jets with interstellar gas, used ALMA to reveal processes hidden by dense cloaks of gas and dust. This was a vital finding for understanding the dynamics between black holes and their influence on galactic evolution. ALMA's unique ability to penetrate these dense regions provides unprecedented insight into these processes. This discovery offers an exceptional look into the forces that shape galaxies and their star components.

Credit: ALMA (ESO/NAOJ/NRAO), NASA/ESA Hubble Space Telescope, T. Nakajima et al.

High demand

Who can observe with ALMA? Ten percent of observation time is allocated to Chile, the host country, while the remaining 90% is distributed among the observatory partners (ESO, NRAO and NAOJ), according to their financial contribution. However, they all contribute observing time toward "open skies" so that any astronomer can apply, regardless of affiliation.

Once a year, ALMA invites the scientific community to submit proposals describing the observations they wish to carry out, what they hope to discover, and how much time they need with ALMA. These proposals are peer-reviewed. To ensure the impartiality of the process, the proposing teams' and the reviewers' identities are not disclosed. Due to high demand, in 2023 only one proposal out of seven was selected for observation.

ALMA will operate for many decades, and it will be used by several generations, including those who are currently elementary and high school students.

Credit: Y. Villalón - ALMA (ESO/NAOJ/NRAO)

Triple star birth: unraveling the mystery with ALMA

An international team used ALMA to investigate IRAS 04239+2436, a triple star system in formation. They discovered gas spiral arms or 'streamers' that transport material to the protostars. These streamers, made visible through sulfur monoxide (SO) emissions, provide clues as to how multiple stars are born. Supercomputer simulations confirmed that these streamers are crucial to star formation. The study revealed that the formation of multiple star systems could follow a hybrid scenario, combining disk fragmentation and gas clouds. This research also shows the complexity of forming planets in such systems, suggesting that turbulent conditions could make the task challenging.

Credit for ALMA images (in boxes): ALMA (ESO/NAOJ/NRAO), J.-E. Lee et al.

Credit for artistic representation (background): ALMA (ESO/NAOJ/NRAO)

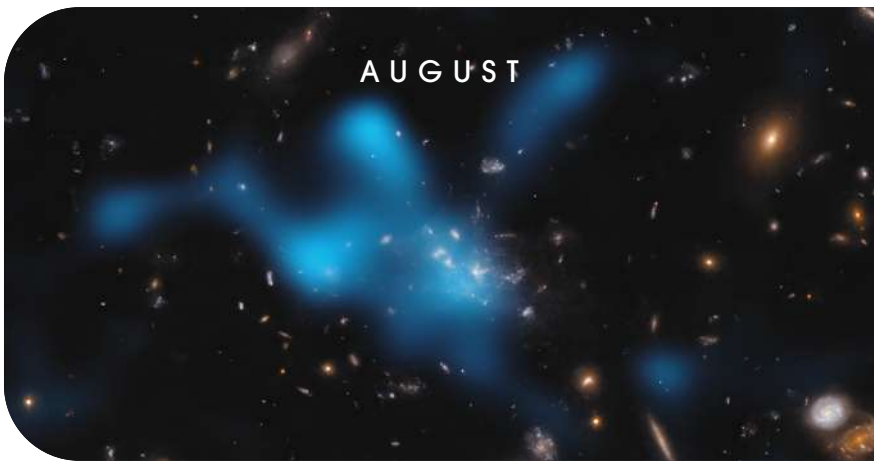
The challenge of changing antenna settings

The Atacama Large Millimeter/submillimeter Array consists of 66 antennas that act together as a single giant telescope. To achieve this, the antennas simultaneously point at the same object in the sky, capturing astronomical signals that are converted into digital format and transmitted to a supercomputer that combines them for scientific analysis.

Increasing the distance between antennas improves the resolution power of the observatory, allowing finer details from the Universe to be captured. Depending on the antenna settings, determined by the needs of the astronomical community, ALMA studies everything from general structures to the finest details of celestial objects.

However, adjusting the antenna settings poses a significant logistical challenge, as each antenna weighs 100 tons. Two custom-built ALMA transporter trucks are used to move them. This engineering feat allows the observatory to explore the Cosmos with unprecedented versatility.

Credit: S. Otárola – ALMA (ESO/NAOJ/NRAO)



Astronomers witness the birth of a very distant cluster of galaxies

ALMA observed a large reservoir of hot gas in a still-forming galaxy protocluster around the Spiderweb galaxy, marking the most distant detection of this type of gas to date. This finding is crucial for understanding the early formation of galaxy clusters, structures that host large numbers of galaxies and an extensive intracluster medium of hot gas. The discovery was made possible by measuring the Sunyaev-Zeldovich effect, which occurs when light from the cosmic microwave background interacts with electrons in hot gas. This finding indicates that the Spiderweb protocluster is on its way to becoming a massive cluster of galaxies, with a mass that could increase at least tenfold over the course of about 10 billion years. This confirms theories about the formation of the largest gravitationally bound objects in the Universe and lays the groundwork for future research using the next generation of telescopes.

Credit: ESO/Di Mascolo et al.; HST: H. Ford

Astronomic virtues of the Atacama Desert

ALMA observes light that is invisible to the naked eye, a light that emanates naturally from objects in the Universe in radio waves, a portion of the electromagnetic spectrum that lets us explore the “cold Universe”. This is not picked up by optic telescopes and is fundamental if we want to know how stars and planets are formed.

The water vapor in the atmosphere absorbs these waves, hindering their collection on Earth. This is why the ALMA antennas were located in one of the most arid areas in the world: the Atacama desert. Due to its dryness, high altitude, scant clouds and scarce radio interference and light pollution from cities, this desert is one of the best places on Earth for astronomic observation.

Despite its similarity with the landscape of Mars, the Atacama Desert is home to endemic flora and fauna, which over centuries have developed techniques to adapt to the rugged living conditions. In the image, a carancho (Southern crested caracara) flies over Chajnantor.

Credit: J. Rojas – ALMA (ESO/NAOJ/NRAO)

First direct image of a black hole expelling a powerful jet

Astronomers have captured the first direct image of the shadow of the black hole at the center of the galaxy Messier 87 (M87) and its powerful jet. This landmark observation, made in 2018 with the Global Millimeter VLBI Array (GMVA), ALMA and the Greenland Telescope (GLT), provides a deeper understanding of how black holes can launch such energetic jets. The collaboration between ALMA, GLT and GMVA has significantly improved the resolution and sensitivity of the observations, revealing crucial details about the ring-like structure and jet of M87. This breakthrough provides information about the nature of the black hole, which absorbs matter at a low rate and raises new questions about the internal dynamics of the region near it, possibly indicating the presence of winds that generate turbulence and chaos. This discovery marks the beginning of future observations to unravel more secrets of M87 and other similar phenomena in the Universe.

Credit for ALMA image (in box): R.-S. Lu (SHAO), E. Ros (MPIfR), S. Dagnello (NRAO/AUI/NSF)

Credit for artistic representation (background): S. Dagnello (NRAO/AUI/NSF)

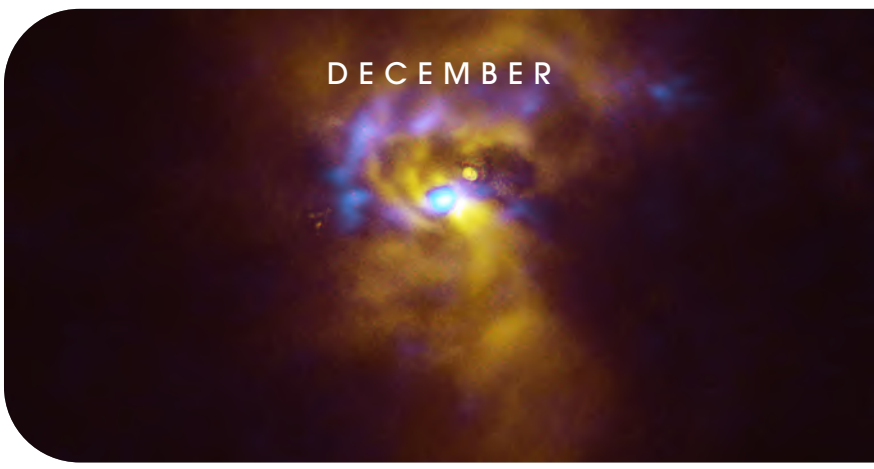
Synchronized to capture the “rain”

In the Chajnantor plateau, a unique “rain” is falling: it is light from space, in millimetric and submillimetric wavelengths, a natural, scarce and precious resource. These waves are full of crucial information about our cosmic origins, drawing in a scientific community thirsty for knowledge to collect, channel and analyze this light. This gives rise to ALMA, the largest radio telescope of its kind.

Thanks to ALMA, the astronomical community can use this light to study the chemical and physical conditions in molecular clouds, which are dense regions of gas and dust where new stars are forming. The main purpose is to study star formation, molecular clouds and the early Universe, closing in on its main goal: discovering our cosmic origins.

The image shows most of the 66 ALMA antennas at sunset, at an altitude of 5,050 meters, working in perfect synchronization.

Credit: Y. Villalón - ALMA (ESO/NAOJ/NRAO)



Star-birth spectacle unveiled from Chile

An international team achieved a groundbreaking observation by studying V960 Mon, a young star located over 5,000 light-years away, which experienced an outburst that explosively increased its brightness. The team found surprisingly large spiral structures surrounding V960 Mon, as well as clumps of solid particles with masses comparable to that of Earth, providing significant insight into the early stages of star and planet formation. This finding, which reanalyzes data from past observations with ALMA and the Very Large Telescope (VLT), directly connects star and planet formation, highlighting the ALMA archive as an invaluable source for astronomical discoveries. Future research will focus on understanding how these features influence the early stages of star and planet formation.

Credit: ESO/ALMA (ESO/NAOJ/NRAO)/Weber et al.

Astronomy in the streets

The fascination that astronomy awakens in people of all ages makes it an exceptional educational tool. It significantly increases interest in science and technology among students, representing a crucial investment for the future of any country.

In this context, ALMA plays a vital role in promoting scientific knowledge among the general public, as well as contributing to the recognition of San Pedro de Atacama as an outstanding tourist destination. This consolidates Chile’s longstanding position as the world’s astronomical capital.

This mural was created by the artist Animahop (Silvana Zúñiga) in San Pedro de Atacama. It combines the Andean vision of the Cosmos with ALMA research. The artistic action was accompanied by a painting and astronomy workshop for children, highlighting the observatory’s commitment to education and art.

Funded by ALMA, this work is part of an initiative that seeks to bring astronomical content to the streets, a particularly important objective in an area that is home to several astronomical observatories.

Credit: PPF Fuentealba – ALMA (ESO/NAOJ/NRAO)

www.almaobservatory.org

Credit: J. Rojas – ALMA (ESO/NAOJ/NRAO)

JANUARY

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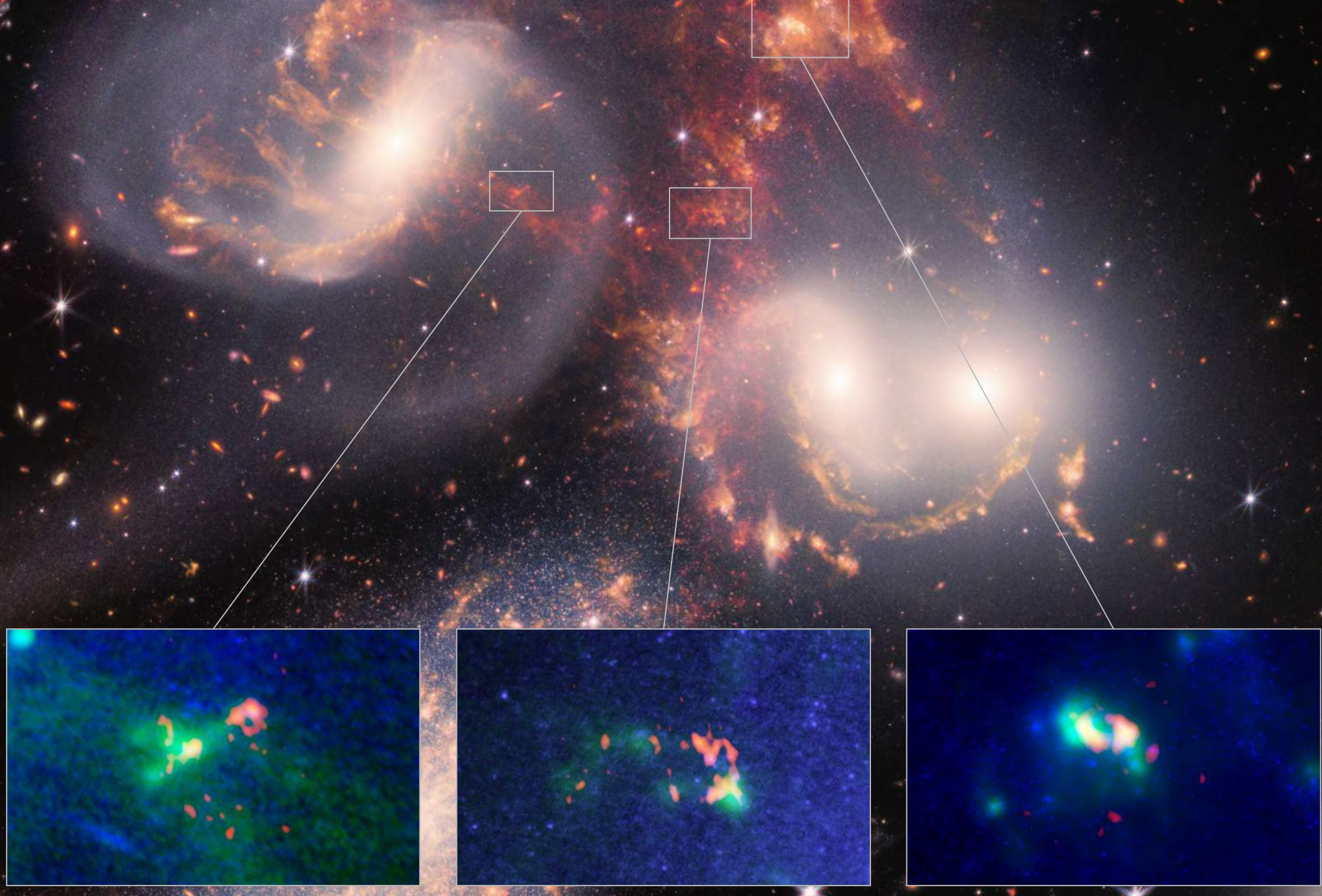

Credit: ALMA (ESO/NAOJ/NRAO)/JWST/ P. Appleton (Caltech), B. Saxton (NRAO/AUI/NSF)

FEBRUARY

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Credit: J. Rojas - ALMA (ESO/NAOJ/NRAO)

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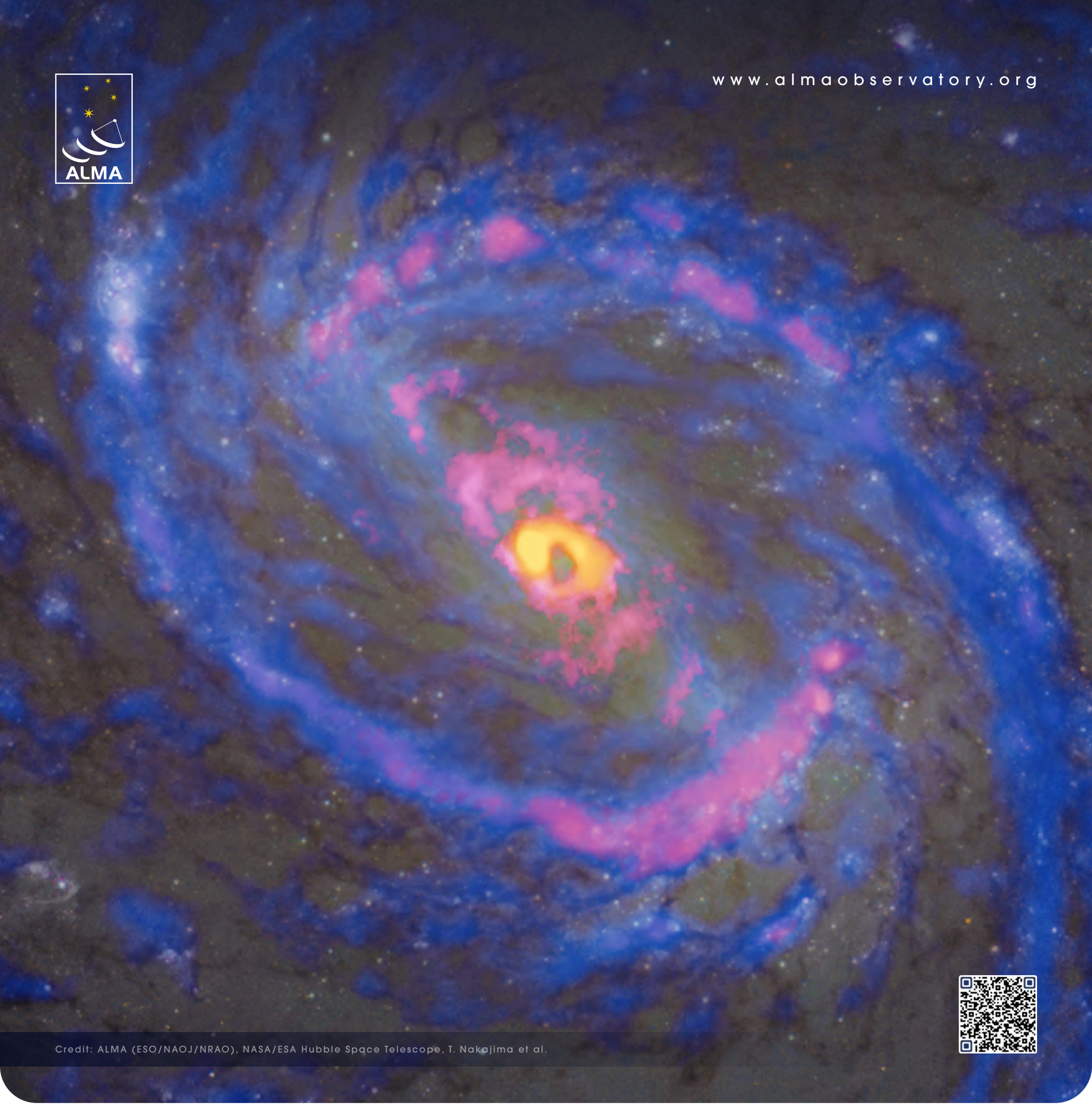

Credit: ALMA (ESO/NAOJ/NRAO), NASA/ESA Hubble Space Telescope, T. Nakajima et al.

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Credit: Y. Villalón - ALMA (ESO/NAOJ/NRAO)

MAY

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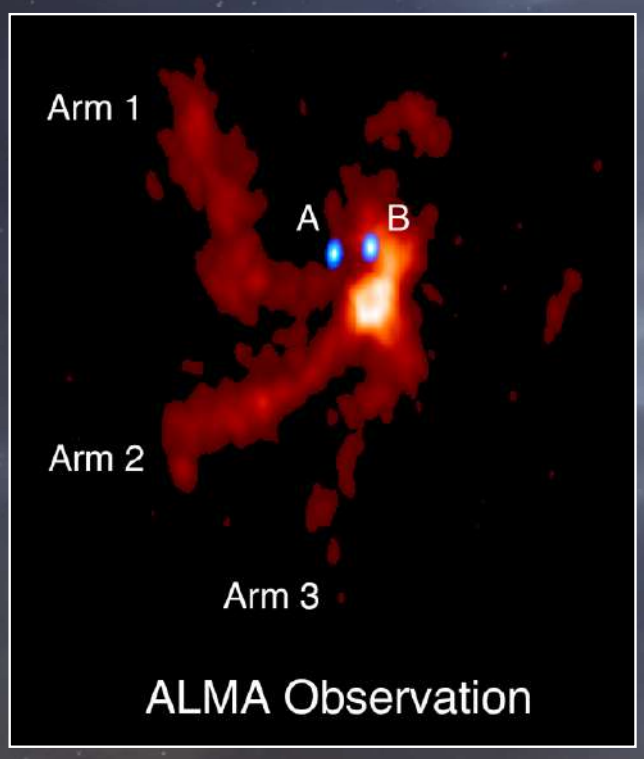

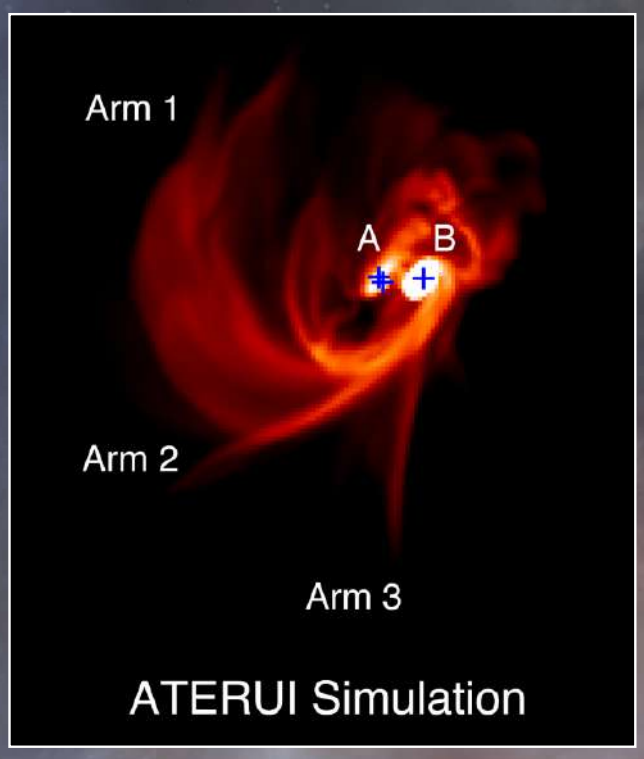

Credit for ALMA images (in boxes): ALMA (ESO/NAOJ/NRAO), J.-E. Lee et al.
Credit for artistic representation (background): ALMA (ESO/NAOJ/NRAO)

JUNE

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Credit: S. Otárola – ALMA (ESO/NAOJ/NRAO)

JULY

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ALMA

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Credit: ESO/Di Mascolo et al.; HST: H. Ford

AUGUST

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ALMA

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Credit: J. Rojas – ALMA (ESO/NAOJ/NRAO)

SEPTEMBER

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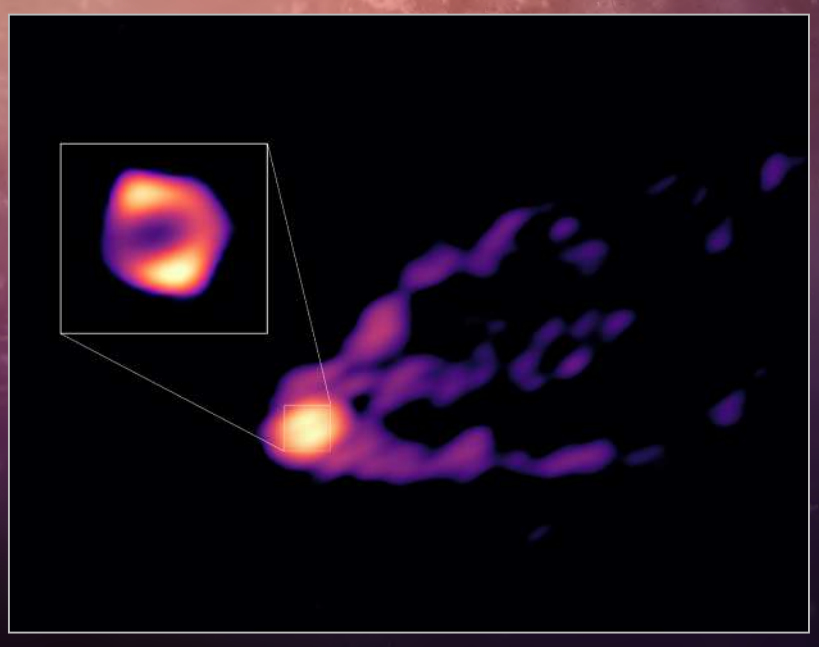

Credit for ALMA image (in box): R.-S. Lu (SHAO), E. Ros (MPIfR), S. Dagnello (NRAO/AUI/NSF)
Credit for artistic representation (background): S. Dagnello (NRAO/AUI/NSF)

OCTOBER

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Credit: Y. Villalón - ALMA (ESO/NAOJ/NRAO)

NOVEMBER

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Astronomical image credit: ESO/ALMA (ESO/NAOJ/NRAO)/Weber et al.
Antenna image credit: P. Carrillo - ALMA (ESO/NAOJ/NRAO)

DECEMBER

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Credit: PPF Fuentealba – ALMA (ESO/NAOJ/NRAO)

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 National Science and Technology Council (NSTC) in Taiwan 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.

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