ALMA

ESO

NAOJ
National Astronomical Observatory of Japan

NRAO

2025 CALENDAR

ALMA.Observatory

ALMA.Radiotelescope

ALMAobservatory

ALMA: Exploring the Secrets of the Universe

Located in the heart of the Atacama Desert, at 5,000 meters above sea level, the Atacama Large Millimeter/submillimeter Array (ALMA) is a testament to what global collaboration can achieve. This unique observatory combines the most advanced technology with the best weather conditions on the planet to study the Universe at millimeter and submillimeter wavelengths, invisible to the human eye.

With 66 high-precision antennas, ALMA enables humanity to explore everything from the origins of water in planetary systems to the formation of stars and galaxies in the distant cosmos. Beyond its scientific discoveries, ALMA symbolizes international cooperation, uniting Europe, North America, East Asia, and Chile in a common mission: to understand our place in the Universe and dream of the future.

Every night and day, under pristine skies, ALMA continues to search for answers to fundamental questions about our origins and destiny in the Cosmos.

Credit: A. Pérez

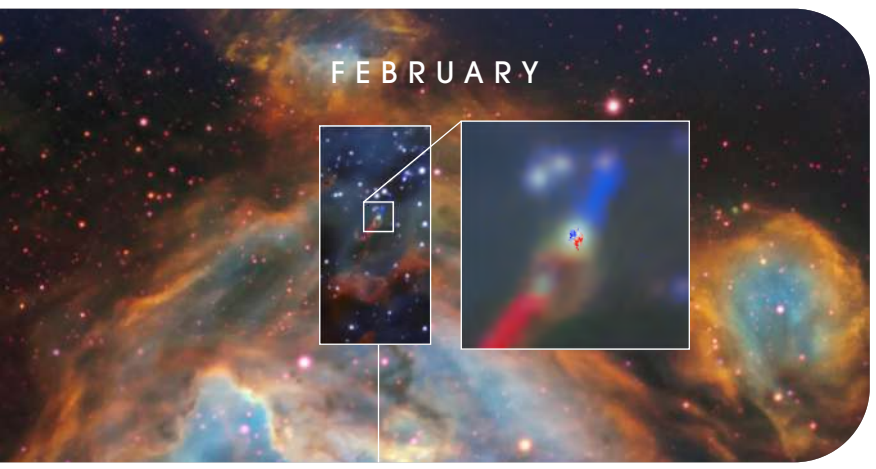
An extreme environment

One of the unique characteristics of ALMA, which makes it an essential tool for making discoveries in the Cosmos, is its high sensitivity. Thanks to this, it can capture wave signals in millimetric and submillimetric lengths, a range invisible to our eyes. It reveals valuable information about the objects observed, such as their structure and chemical composition.

To carry out this feat of science and engineering, cutting-edge technology, particular climatic conditions, enormous precision in the use of instruments and top-level professionals are needed to calibrate and maintain its 66 antennas.

ALMA has a department dedicated to antenna maintenance, which comprises more than 60 people, technicians, and engineers who often face extreme conditions on the Chajnantor plain, which is more than 5,000 meters above sea level. In the image, two of them are ready to clear the snow.

Credit: P. Bello – ALMA (ESO/NAOJ/NRAO)



Disc discovered around a star in another galaxy

Using the ALMA observatory, an international scientific team has detected a disc around a young star in another galaxy for the first time. The discovery was made in the Large Magellanic Cloud, a galaxy close to the Milky Way, and the star in question is a massive star called HH 1177.

The observed disc is similar to those that form planets in our galaxy, indicating that planetary formation may be a common phenomenon throughout the Universe. The data revealed a rotating disc of dense gas around the star, confirming that discs play a crucial role in forming stars and planets. This important discovery, published in the journal Nature, provides us, for the first time, with direct evidence of the star formation process in another galaxy.

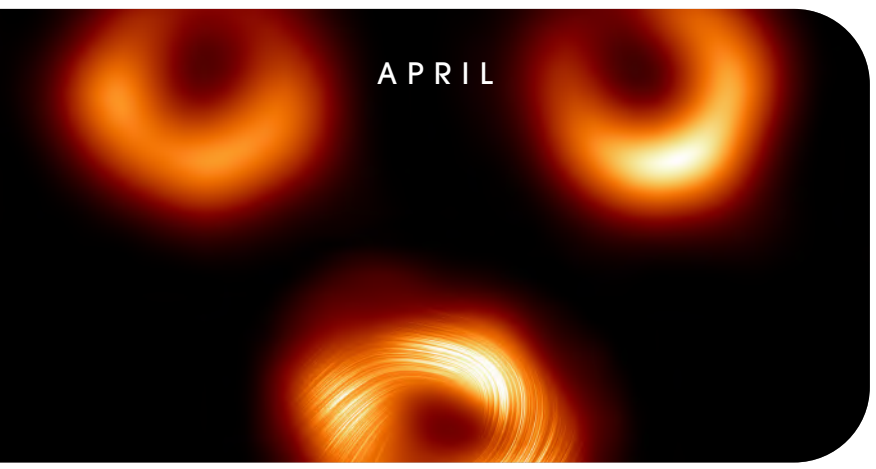
Credit: ESO/ALMA (ESO/NAOJ/NRAO)/A. McLeod et al.

The Cosmos within reach of the public

ALMA has a fascinating story to tell, a story of discoveries that, in turn, opens the door to new questions about our place in the Cosmos. More than an observatory, ALMA is also a living example of global collaboration, with partners from 3 continents (ESO, NRAO, and NAOJ) and the invaluable contribution of Chile, demonstrating how joint work expands the frontiers of knowledge. It is located in Chile, the astronomical capital for its pristine skies, with more than 40% of the world's astronomical observation capacity. This figure is estimated to reach 70% by the end of this decade.

The expectations around ALMA transcend the purely scientific, entering the sphere of dreams and imagination. Humanity seeks to answer some of its most profound questions through antennas: Are we alone in the Universe? What are our cosmic origins and our future? The observatory shares those dreams with a broad and diverse community of scientists, students, media, and the public.

Credit: ALMA (ESO/NAOJ/NRAO)



New evidence on black holes

The Event Horizon Telescope (EHT) Collaboration published new advances that have improved the understanding of black holes, specifically in Sagittarius A* (center of the Milky Way) and M87*. In Sagittarius A*, they detected highly intense magnetic fields at the edge of the black hole. These magnetic fields seem to influence the behavior of the gas and material that falls into its interior, providing key clues about the processes that occur in these extreme regions. In the case of M87*, observations made a year after the first image of its shadow confirmed this structure's persistence, which validates Einstein's theory of general relativity and provides solid evidence of its behavior.

Both discoveries represent important advances in astrophysics, helping to understand better the mysteries of black holes and their surroundings, such as the emission of jets of matter and the interaction with their magnetic fields.

Credit: EHT Collaboration

The giants that move ALMA

The antenna transporters, Otto and Lore, are essential for the observatory's operation. Not only must they move 100-ton antennas with millimetric precision, but they must reach up to 5,000 meters of altitude with them! This trip can take up to 7 hours from the ALMA camp, located at 2,900 meters above sea level.

They are also required for another mission: periodically reconfiguring the location of the antennas at Chajnantor moving them between 192 different platforms to adjust the type of observation. If the 66 antennas are grouped in an area just 150 meters in diameter, they capture wider images; if they are spread out over 16 kilometers, they can capture greater detail of distant objects, like a camera zoom. Moving these gigantic antennas is no easy task. Otto and Lore are equipped with motors as powerful as two Formula 1 cars, ensuring this work is done safely and efficiently.

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

New link between water and planet formation revealed

A scientific collaboration used ALMA to discover water vapor in the protoplanetary disk of the young star HL Tauri, located 450 light years from Earth. This finding, published in Nature Astronomy, revealed that water is present where planets could be forming. This suggests that the amount of water vapor in protoplanetary disks can influence the composition of the planets that develop there. The research highlights the essential role of water in planetary formation, providing a new perspective on the processes that occurred in the early Solar System.

This discovery not only improves our understanding of the origin of water on planets but could also help astronomers study planets outside our Solar System and determine how their atmospheres are formed.

Astronomical image credit: ALMA (ESO/NAOJ/NRAO)/S. Facchini et al. / Antenna image credit: A. Pérez

www.almaobservatory.org

Credit: P. Bello – ALMA (ESO/NAOJ/NRAO)

JANUARY

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

FEBRUARY

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Credit: ALMA (ESO/NAOJ/NRAO)

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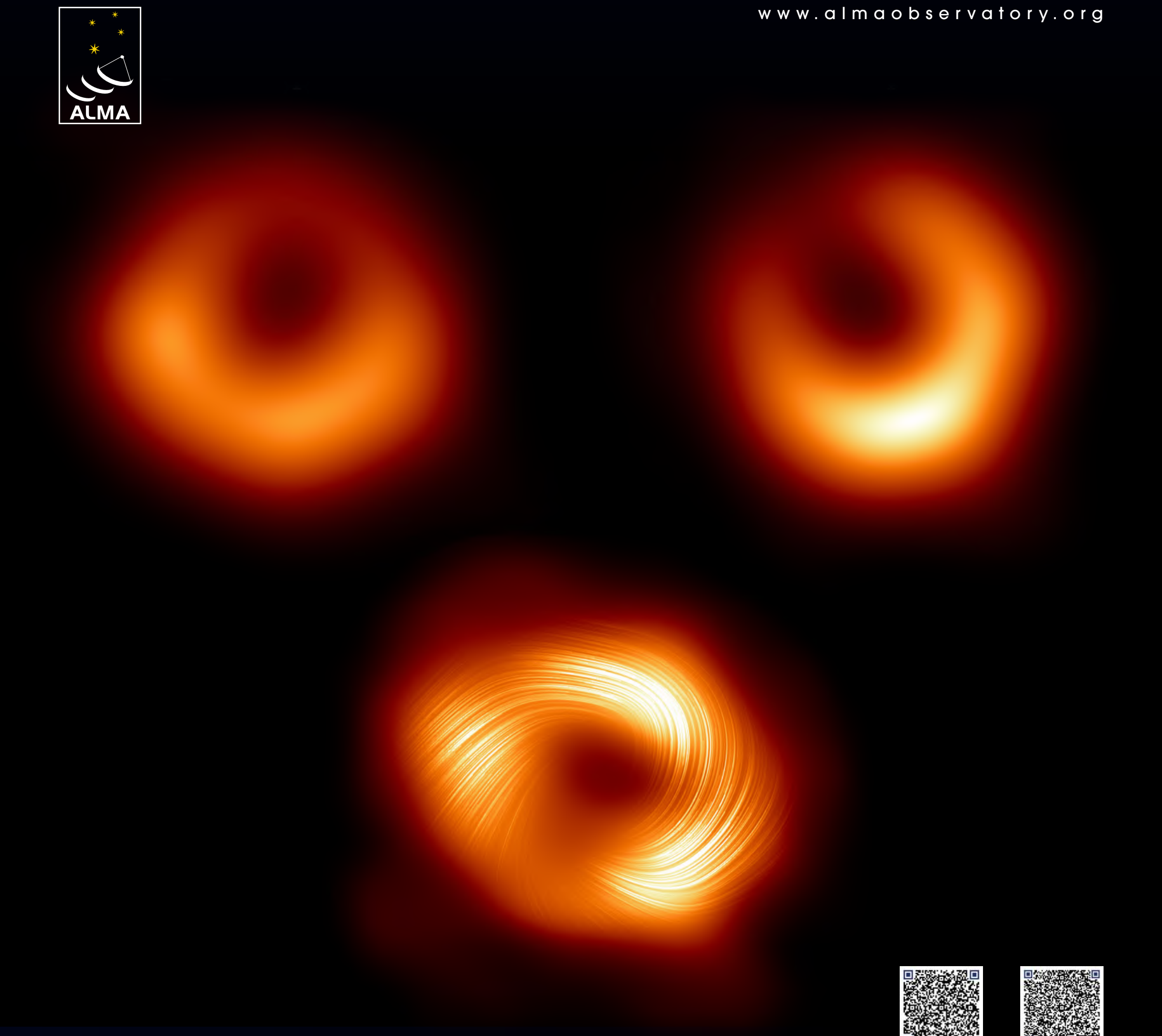

Credit: EHT Collaboration

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

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Astronomical image credit: ALMA (ESO/NAOJ/NRAO)/S. Facchini et al.
Antenna image credit: A. Pérez

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

JULY

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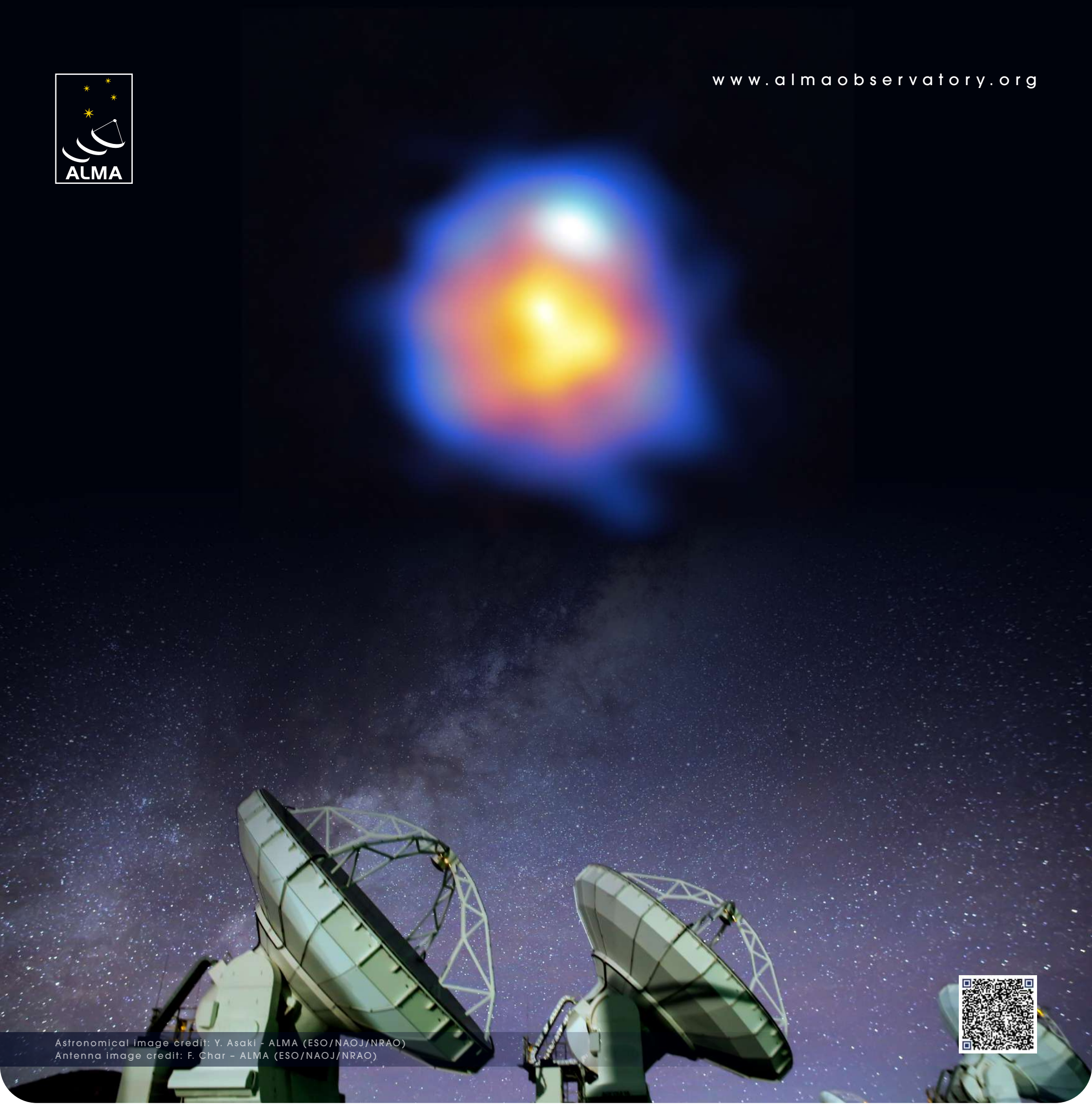

Astronomical image credit: Y. Asaki - ALMA (ESO/NAOJ/NRAO)
Antenna image credit: F. Char – ALMA (ESO/NAOJ/NRAO)

AUGUST

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Credit: F. Char - ALMA (ESO/NAOJ/NRAO)

SEPTEMBER

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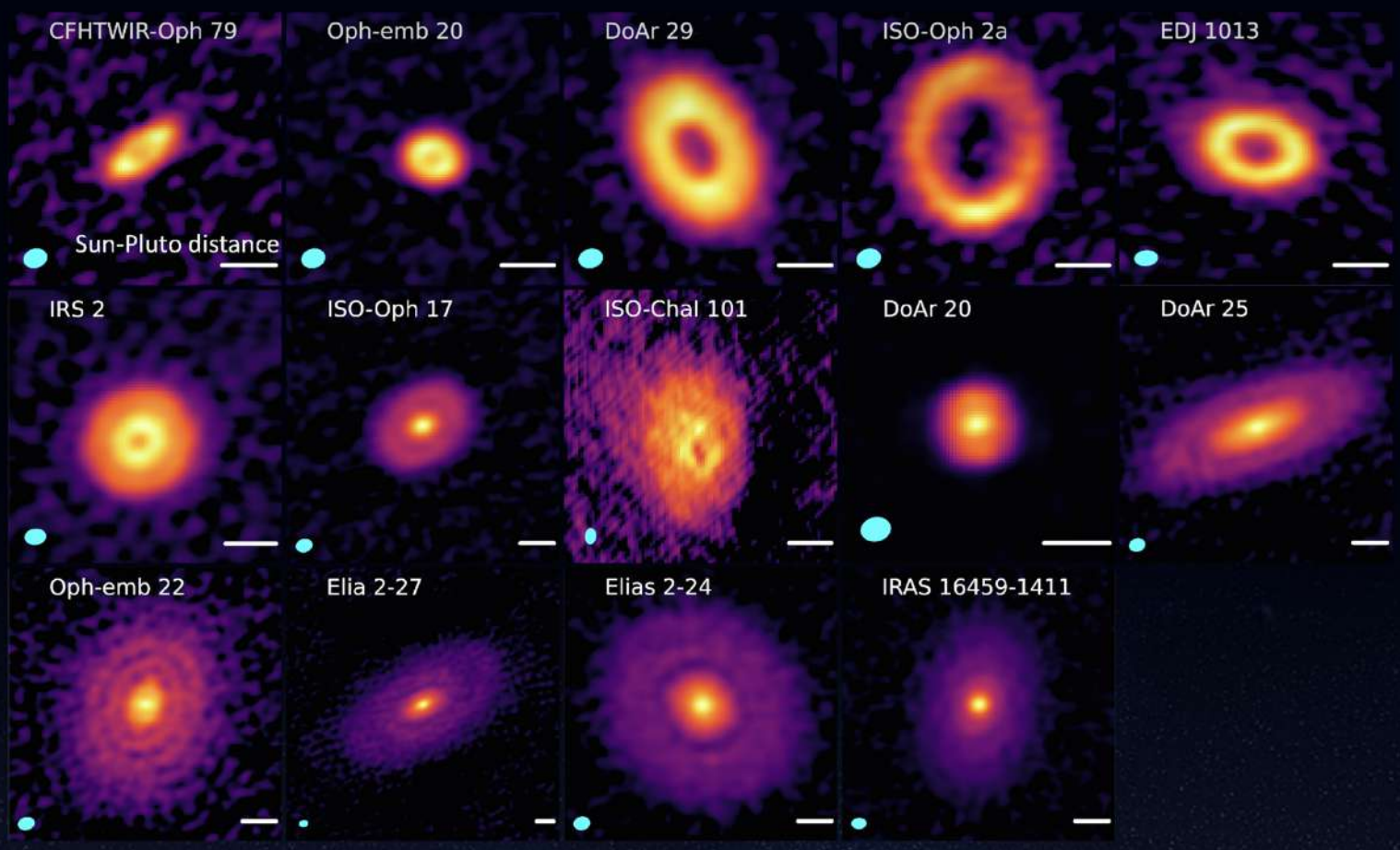

Credit for astronomical images: Hsieh et al. – ALMA (ESO/NAOJ/NRAO)
Image credit for antennas: A. Pérez

OCTOBER

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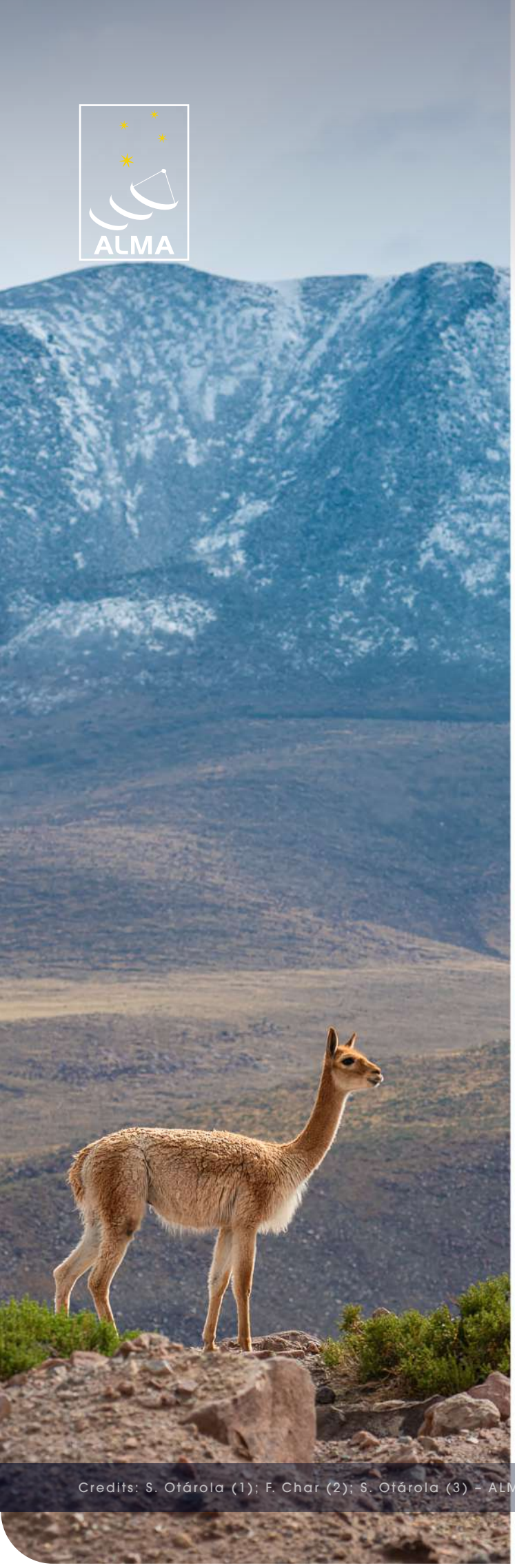

Credits: S. Otárola (1); F. Char (2); S. Otárola (3) – ALMA (ESO/NAOJ/NRAO)

NOVEMBER

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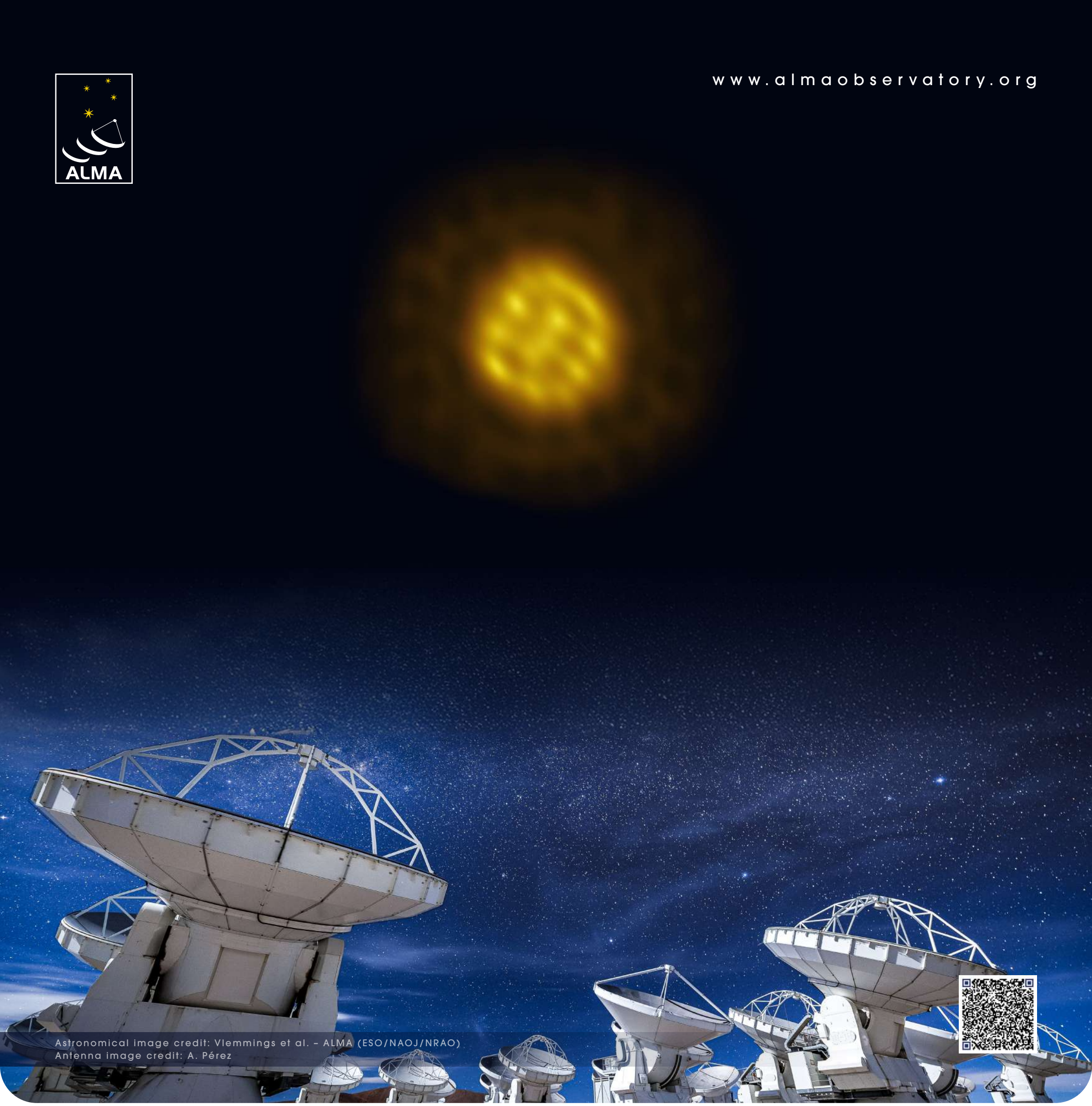

Astronomical image credit: Vlemmings et al. – ALMA (ESO/NAOJ/NRAO)
Antenna image credit: A. Pérez

DECEMBER

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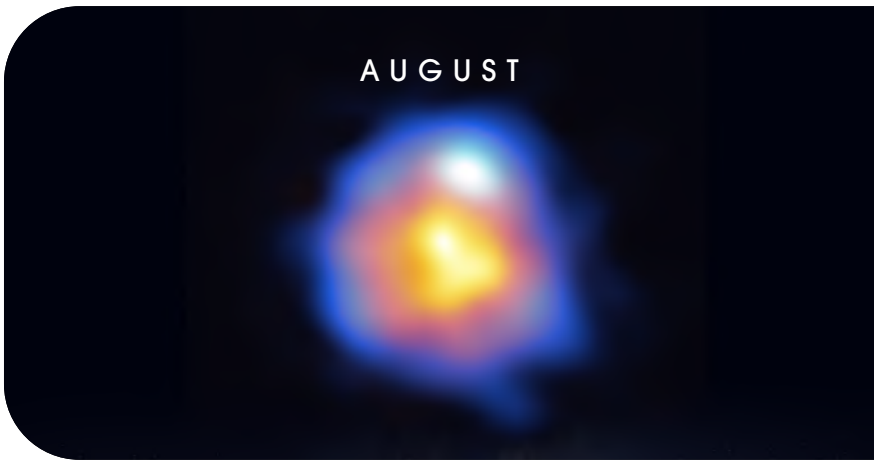
Revealing secrets from the Andean plateau

Amid the extreme environmental conditions of the Chajnantor plateau, at 5,000 meters above sea level, ALMA's antennas operate day and night, allowing the astronomical community to study the light from some of the coldest and most hidden objects in the Universe. From the birth of stars and the formation of planets to the most distant galaxies ever captured.

ALMA was installed in this particular environment due to its atmospheric conditions. The geographic altitude in the driest desert in the world reduces the presence of water vapor, which absorbs millimeter and submillimeter radiation, precisely what the ALMA antennas capture.

In the image, two of the observatory's 66 high-precision antennas can be seen, most with a diameter of 12 meters. This cutting-edge project is located in an environment that is as ideal for astronomy as it is challenging for those who must maintain its operation in these extreme and isolated conditions.

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



Historic milestone: ALMA reaches its maximum angular resolution

The ALMA observatory achieved a historic milestone by reaching its maximum angular resolution, allowing the observation of details never seen before in the Universe. Using the Band-to-Band (B2B) observation technique and distributing its antennas over a radius of up to 16 kilometers, the observations achieved a resolution of 5 milliarcseconds. This capacity is equivalent to seeing a bus on the surface of the Moon from Earth.

This advance allowed R Leporis, a star in the final stages of its life, to be observed with unprecedented precision. This achievement represents a new era for astronomical observation since the scientific community can now explore distant objects with a better resolution than ever before. This opens the door to future research into the formation of stars, planets, and other cosmic phenomena, which were previously impossible to study in such detail.

Astronomical image credit: Y. Asaki - ALMA (ESO/NAOJ/NRAO)

Antenna image credit: F. Char – ALMA (ESO/NAOJ/NRAO)

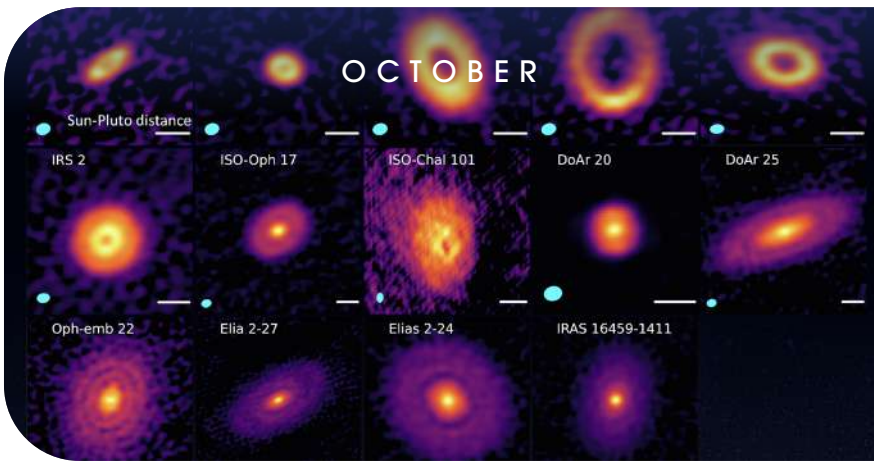
Modern Astronomy and Ancestral Roots

The Shader seen in the image is a curved and perforated steel structure, which projects the location of the stars in the night sky as seen from the southern hemisphere. This iconic piece is a landmark for any visitor to the observatory.

Located next to the Estancia de la Abuela, which belonged to the Sombreador (shade projector), a space that connects the past and present in the observation of the sky, was built with two rooms (bedroom-kitchen and cellar-visitor accommodation) using stones and cactus, traditional materials from the ecosystem where these shepherds lived for hundreds of years, between 2,500 and 3,500 meters above sea level.

In this way, the Sombreador and the Estancia de la Abuela are key pieces to start the ALMA tour, presenting who were the ones who began to observe the Universe from this corner of the planet and their worldview.

Credit: F. Char – ALMA (ESO/NAOJ/NRAO)



Planetary formation could begin earlier than previously thought

Using ALMA, a scientific team managed to observe for the first time the early evolution of the structures of extremely young planetary disks, less than 300,000 years old. The images show ring-like and spiral-like structures, indicating that planetary formation may begin earlier than previously thought, even at very early stages of stellar evolution. This discovery suggests that giant planets may begin their growth much faster than anticipated and provides new clues to understanding the birth of planetary systems.

This discovery reinforces the importance of studying younger disks to understand better how and when planets begin to form, which is changing the paradigm of the evolution of planetary systems. With this data, astronomers can redefine the timing of planetary formation and better understand the mechanisms that drive the process.

Credit for astronomical images: Hsieh et al. – ALMA (ESO/NAOJ/NRAO) / Image credit for antennas: A. Pérez

A unique safari

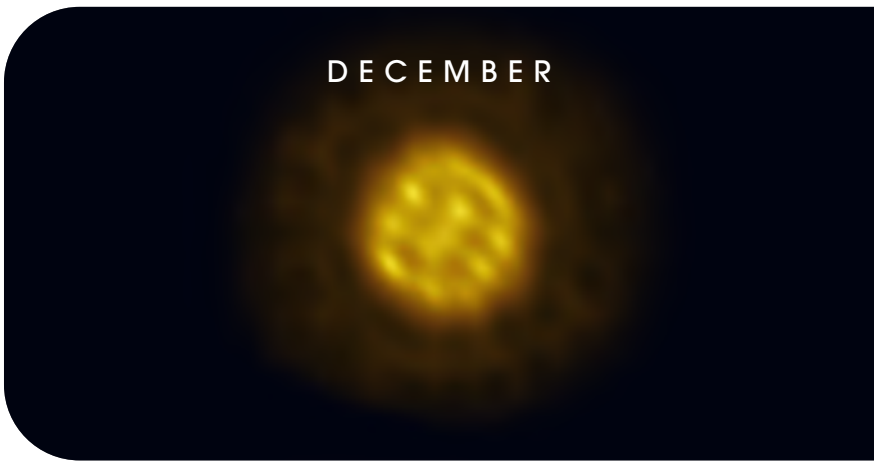
These images show some spectacular animals in the ALMA habitat: a vicuña, donkeys, and a vizcacha. To protect them, the observatory has an environmental management team. Even before its inauguration, experts were commissioned to investigate this heritage and propose key initiatives for its protection.

The construction of ALMA has had a firm commitment to the environment and local culture, protecting unique species of flora and fauna and preserving ancient highland estancias.

Animals such as the llama, the fox, or the condor not only live in the region but are part of the same sky that ALMA is exploring, as they are essential elements in the ancestral Andean constellations.

To protect the excellent environmental conditions of the Chajnantor plateau, which make this place unique for radio astronomy, the Government of Chile declared a large part of this area as a scientific reserve.

Credits: S. Otárola (1); F. Char (2); S. Otárola (3) – ALMA (ESO/NAOJ/NRAO)



ALMA obtained the most detailed video yet of bubbling gas on the surface of a star

An astronomical team used ALMA to obtain the most detailed video of bubbling gas on the surface of a red giant star, R Doradus, located 180 light years from Earth. The enormous bubbles of hot gas confirm the presence of an intense convection process that moves the gas and distributes heavy elements, a key phenomenon for understanding the evolution of stars. The stellar winds emanating from R Doradus are vital in its life cycle and material dispersion into interstellar space. Observing these details on a star other than the Sun provides a unique opportunity to study the dynamics of the stellar surface and the processes that occur in the advanced stages of a giant star's life. The detailed images obtained with ALMA allow the astronomical community to understand better these processes and their implications for stellar evolution.

Astronomical image credit: Vlemmings et al. – ALMA (ESO/NAOJ/NRAO) / Antenna image credit: A. Pérez

Innovating at the frontier of knowledge

ALMA has been a leader in millimeter and submillimetre wave observations for over a decade, making discoveries that expand the frontiers of knowledge about the Universe. To remain a pioneer in astronomy and continue producing high-quality scientific data, a Roadmap for the Future Development of ALMA has been defined, which sets a new and ambitious goal: the Wideband Sensitivity Upgrade (WSU), expected by 2030.

This revolutionary change promises to transform astronomy as we know it, significantly expanding ALMA's capacity and broadening its scientific reach in the coming decades. The plan calls for doubling and eventually quadrupling its bandwidth, accompanied by upgrades to the WSU.

The challenge is immense: deploying a "new telescope" while the current one continues to operate. With the WSU, ALMA will secure its position as a world leader in the search for our cosmic origins.

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

Credit: M. López – 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.

ALMA National Astronomical Observatory of Japan ESO NRAO

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