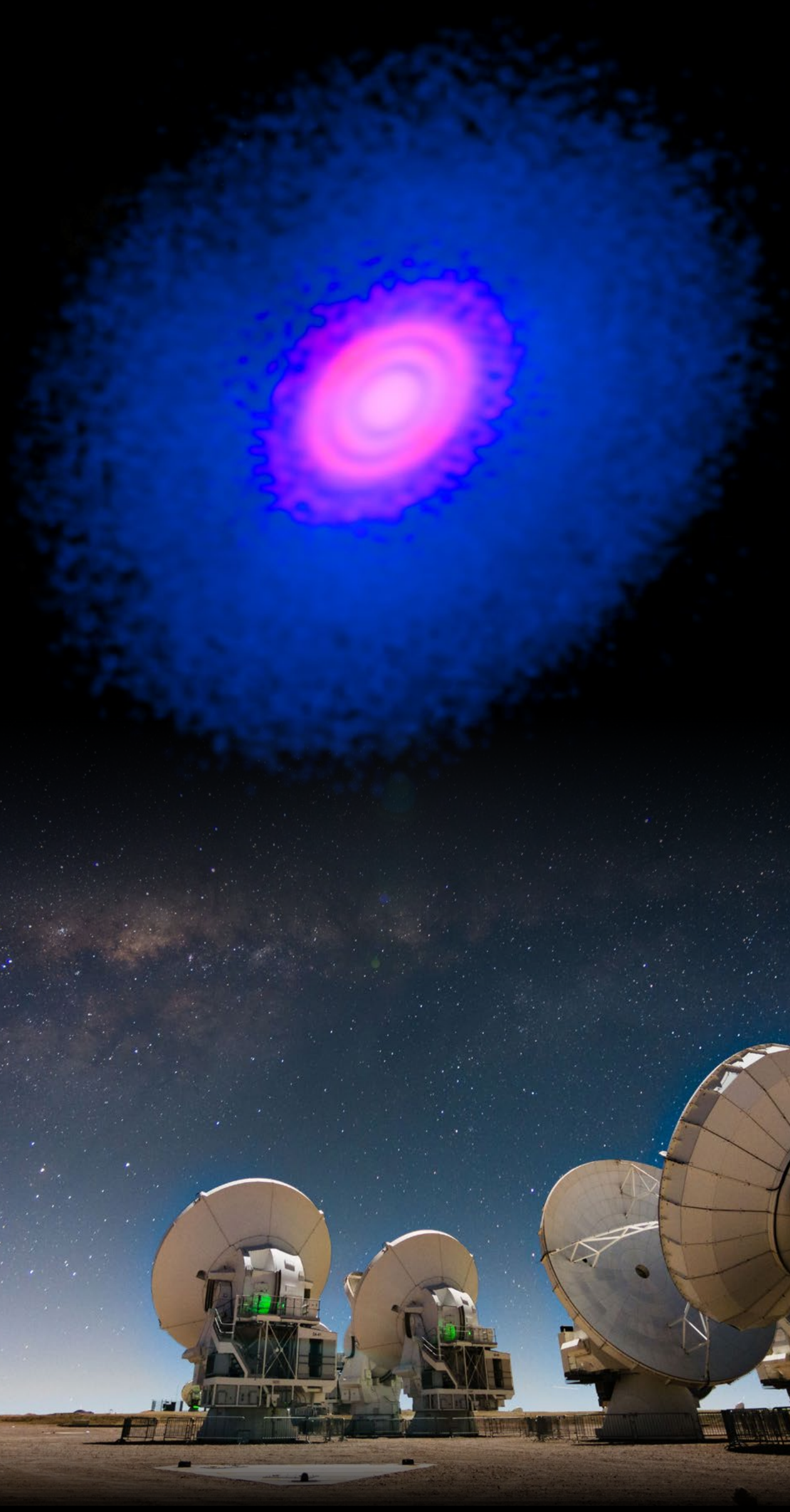
2018 CALENDAR

ALMA ESO NAOJ National Astronomical Observatory of Japan NRAO



JANUARY

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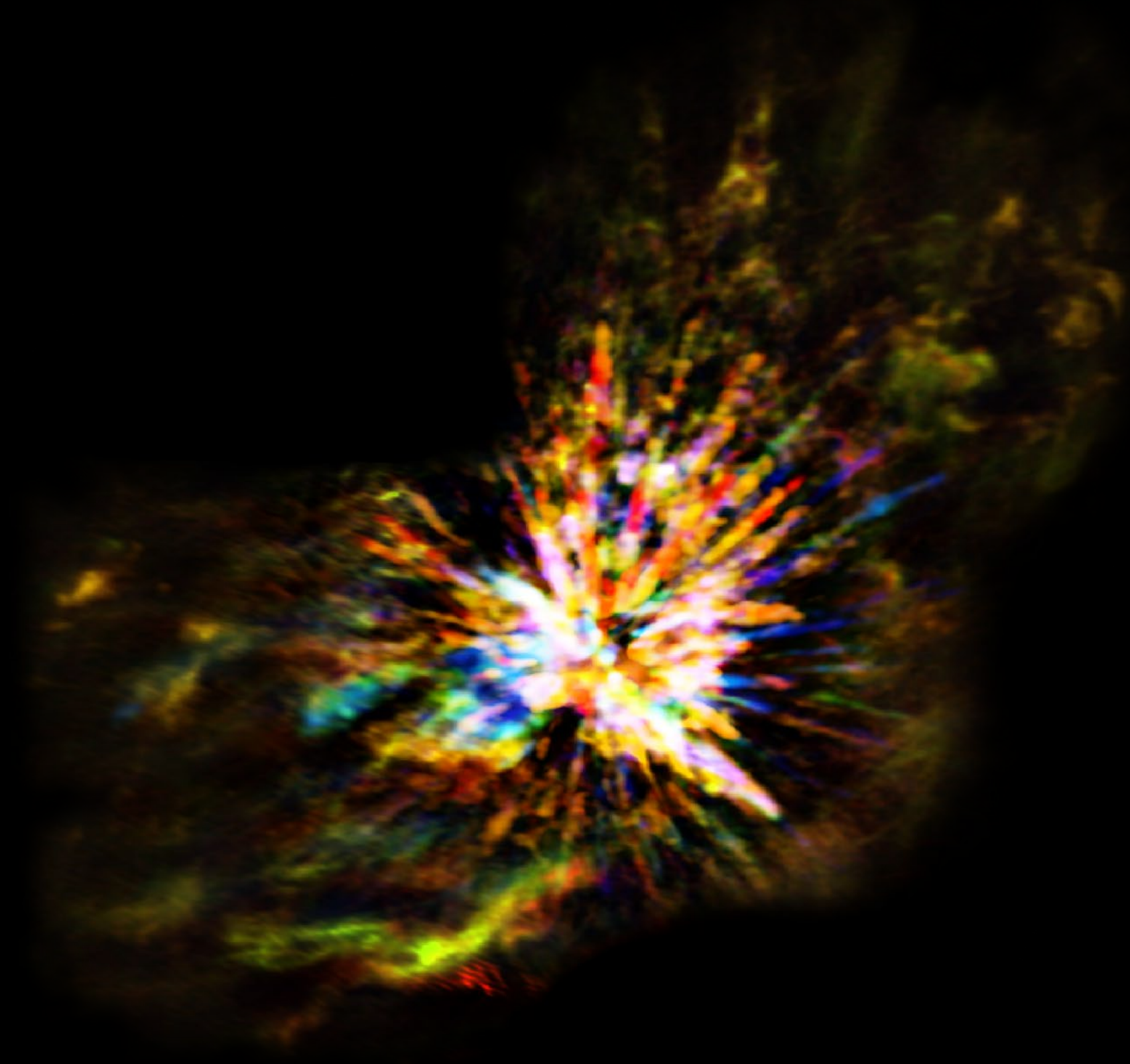

FEBRUARY

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MARCH

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MAY

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ALMA

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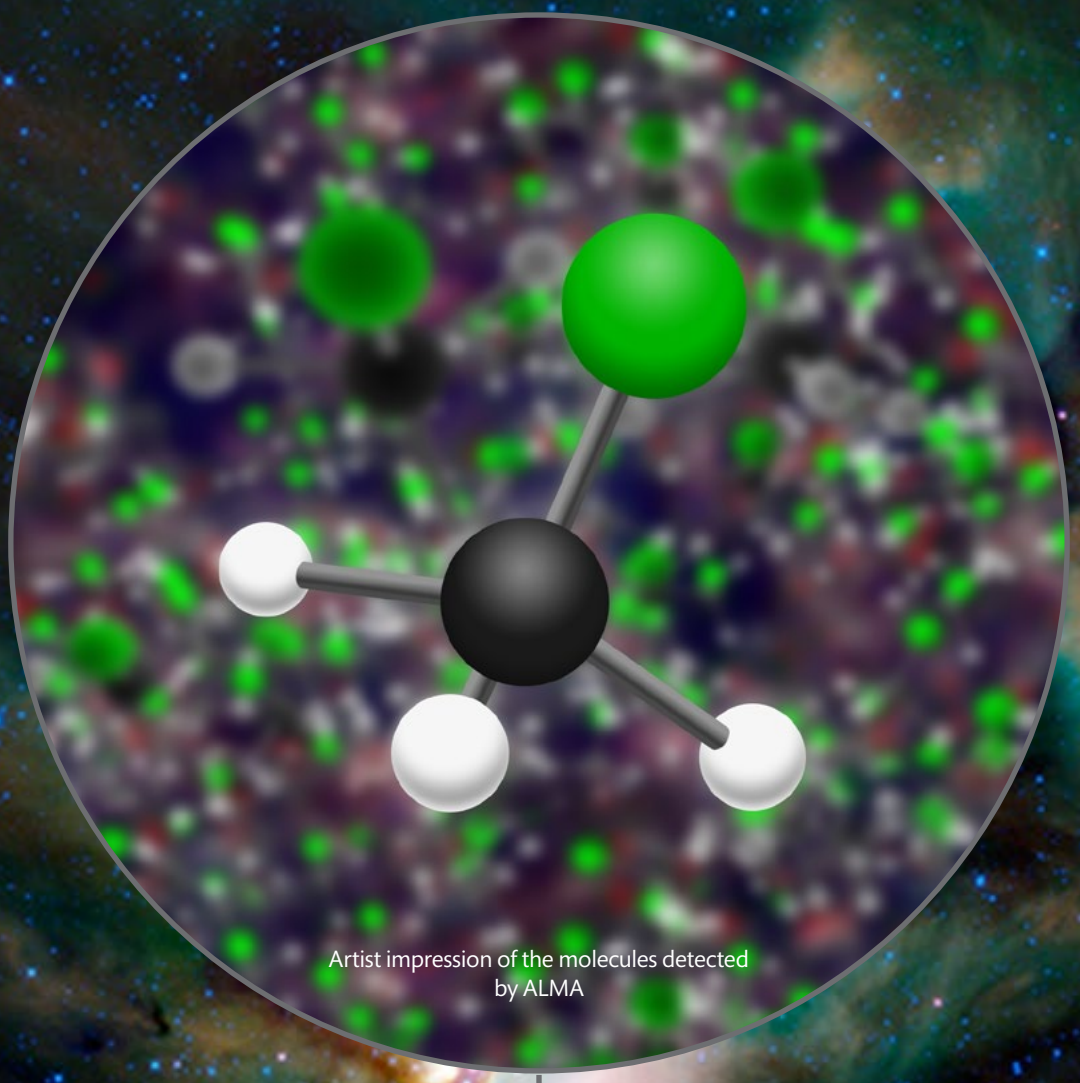

Artist impression of the molecules detected by ALMA

JULY

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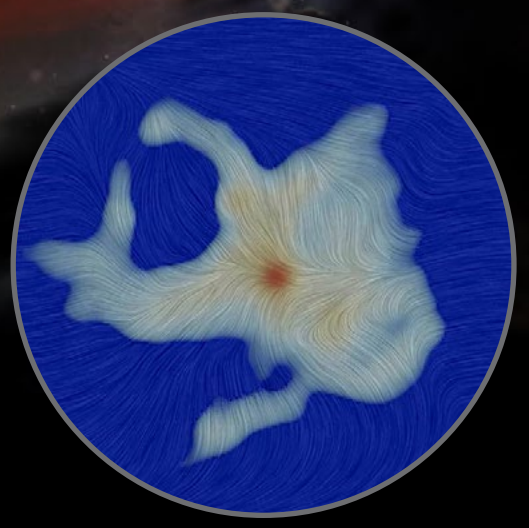
Artist impression



Astronomical image

SEPTEMBER

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OCTOBER

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Artist impression

Astronomical image

DECEMBER

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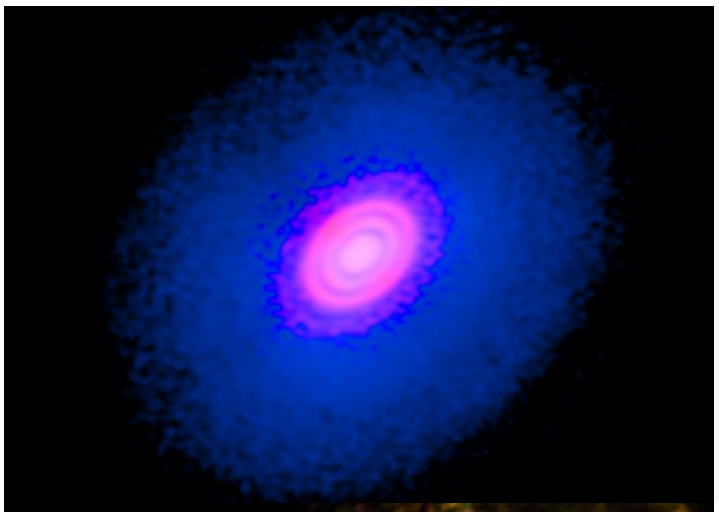


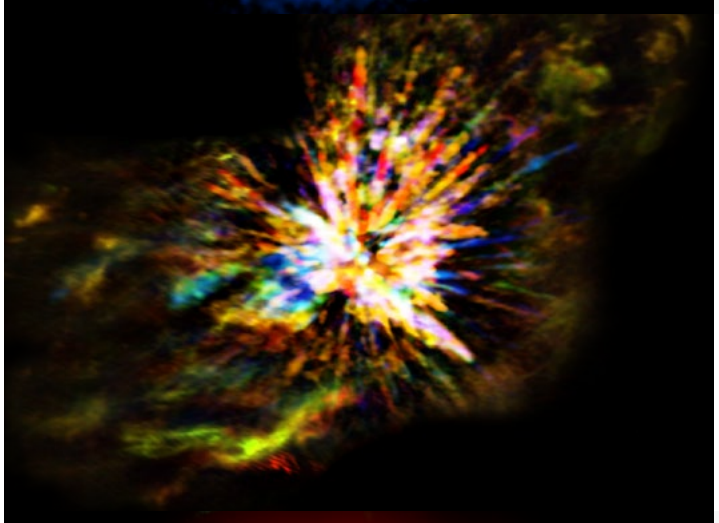
January - Early planet formation?

We now know that beyond the Solar System, our galaxy is teeming with planets, from rocky worlds roughly the size of Earth to gas giants bigger than Jupiter. Nearly every one of these exoplanets has been discovered in orbit around a mature star with a fully evolved planetary system.

New observations with ALMA contain compelling evidence that two newborn planets, each about the size of Saturn, are in orbit around a young star known as HD 163296. These planets, which are not yet fully formed, revealed themselves by the dual imprint they left in both the dust and the gas portions of the star's protoplanetary disk.

Previous observations of other young star systems have helped to reshape astronomers' understanding of planet formation. For example, ALMA's images of HL Tauri and TW Hydrae revealed striking gaps and prominent ring structures in the stars' dusty disks. These features may be the tantalizing first signs that planets are being born. Remarkably, these signs appeared around much younger stars than astronomers thought possible, suggesting that planet formation can begin soon after the formation of a protoplanetary disk.

Credit: ALMA (ESO/NAOJ/NRAO); A. Isella; B. Saxton (NRAO/AUI/NSF) | **Antennas image:** Sergio Otárola - ALMA (ESO/NAOJ/NRAO)

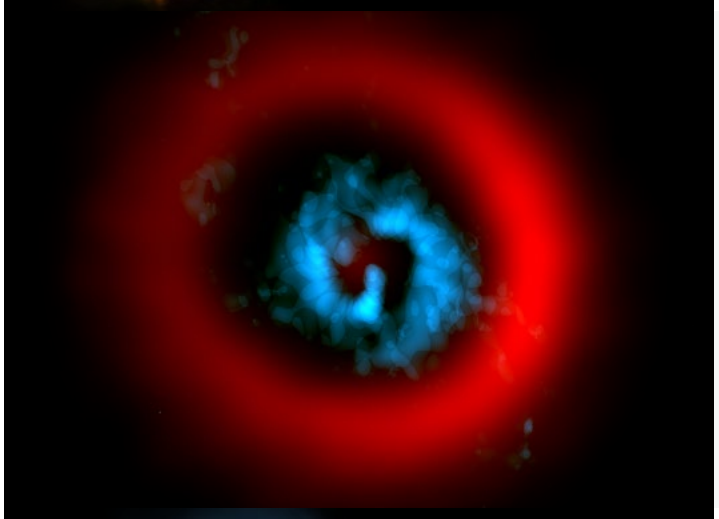


February - Newborn stars destroy their nursery

Star birth can be a violent and explosive event, as dramatically illustrated in new ALMA images. Around 500 years ago, a pair of adolescent protostars had a perilously close encounter that blasted their stellar nursery apart. Astronomers used ALMA to examine the widely scattered debris from this explosive event, gaining new insights into the sometimes-fierce relationship among sibling stars.

Shortly after starting to form some 100,000 years ago, several protostars in the Orion Molecular Cloud 1, a dense and active star factory about 1,500 light-years from Earth just behind the Orion Nebula, latched onto each other gravitationally and gradually drew closer. Eventually, two of these stars either grazed each other or collided, triggering a powerful eruption that launched other nearby protostars and hundreds of giant streamers of dust and gas into interstellar space at speeds greater than 150 kilometers per second. This cataclysmic interaction released as much energy as our Sun emits over the course of 10 million years. Today, the remains of this spectacular explosion are visible from Earth.

Credit: ALMA (ESO/NAOJ/NRAO), J. Bally



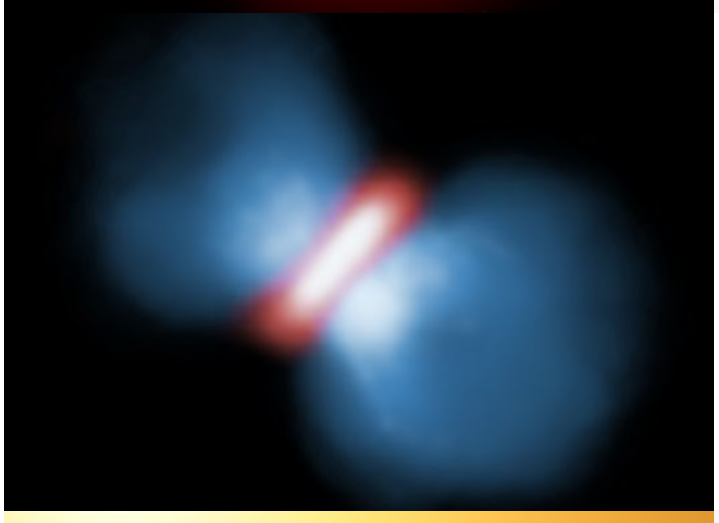
March - Detecting evidence of planets being formed

Planets form within disks composed of dust grains and gas. Planets can gather dust grains from their orbits, resulting in dust gaps or cavities, and can also cause spiral waves within the parental disks based on theoretical predictions. To understand where and when planets can form at early stages, ALMA's capability of seeing disk material with high resolution can depict smoking-gun evidence of infant planets hidden in disks.

Both dust gaps and spirals have been seen separately in a handful of disks. The new ALMA images of AB Aurigae clearly depict gas spirals inside a wide dust gap, and might indicate that there are at least two planets within this system.

One planet that maintains a distance from its star equivalent to 80 times the distance between the Sun and Earth is required to create the sharp dust ring. An additional planet at 30 times this distance or closer to the star is required to produce such spirals.

Credit: ALMA (ESO/NAOJ/NRAO)/Tang et al. | **Antennas image:** Sergio Otárola - ALMA (ESO/NAOJ/NRAO)



April - The birth cry of a massive baby star

Stars are formed from dust and gas present in interstellar space. But, astronomers do not yet fully understand how it is possible to form the massive stars seen in space. One key issue is gas rotation. The parent cloud rotates slowly in the initial stage and the rotation becomes faster as the cloud shrinks due to self-gravity. Stars formed in such a process should have very rapid rotation, but this is not the case. The stars observed in the Universe rotate more slowly.

How is the rotational momentum dissipated? One possible scenario involves the gas emanating from the system. If the gas outflow rotates, it can carry rotational momentum away from the system. The new ALMA observations of Orion KL Source I in the famous Orion Nebula, beautifully illustrate the rotation of the outflow, in the same direction as the gas disk surrounding the star. This strongly supports the idea that the outflow plays an important role in dissipating the rotational energy.

Credit: ALMA (ESO/NAOJ/NRAO), Hirota et al. | **Antennas image:** Jaime Guarda - ALMA (ESO/NAOJ/NRAO)

May - Privileged setting

In the last decades, Chile has become a leading country in the field of astronomy. The climatological and geographic characteristics of the Atacama Desert in northern Chile, which ensure the clarity of its skies, added to the high Andean mountain range provide unique conditions on Earth.

Located approximately 23° south latitude, the ALMA observatory is enclosed by the Andes mountains, near the point where Chile, Bolivia and Argentina meet, dominated by the Salar de Atacama and the Domeyko mountain range.

Despite its similarity to the landscape of Mars, the Atacama Desert is home to endemic flora and fauna, which for centuries have developed survival techniques adapted to harsh local conditions. ALMA workers often come face to face with wild flora and fauna who are used to these adverse living conditions, such as vicuñas , vizcachas, flamingos, foxes, cardon cactus, rica-rica and llareta, plants and animals who inhabit this remarkable landscape.

This family of vicuñas contemplates the wonders of the landscape at sunset, just before ALMA kicks off a new day of astronomical observations in search of our cosmic origins.

Credit: Pablo Carrillo - ALMA (NRAO/NAOJ/ESO)

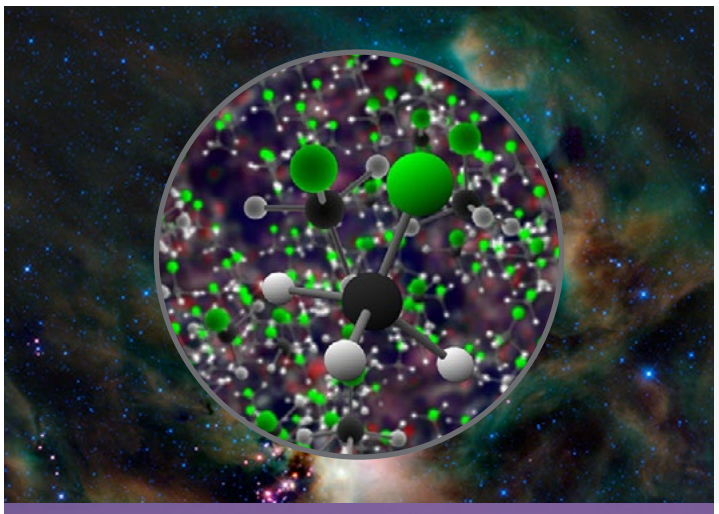
June - ALMA confirms ability to see a "cosmic hole"

A research team used ALMA to investigate hot gas to understand the nature and evolution of galaxy clusters. Even though the hot gas does not emit radio waves detectable with ALMA, the gas scatters the radio waves of the cosmic microwave background and makes a "hole" around the galaxy cluster. This is the Sunyaev-Zel'dovich, or SZ, effect.

Relatively smooth and widely-distributed objects, such as the hot gas in galaxy clusters, are difficult to image with high-resolution radio interferometers. To overcome this difficulty, ALMA utilized the Atacama Compact Array (ACA), whose smaller diameter antennas and the close-packed antenna configuration provide a wider field of view.

With ALMA, the team obtained an SZ effect image of RX J1347.5-1145, with twice the resolution and ten times better sensitivity than previous observations, obtaining an image that better illustrates the pressure distribution of hot gas.

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



July - How to find life in the Universe

Observations made with ALMA and samples from European Space Agency's Rosetta mission, have detected the faint molecular fingerprint of methyl chloride in gas, a chemical commonly produced by industrial biological processes on Earth, around both an infant star and a comet. Methyl chloride, also known as Freon-40, is one of a class of molecules known as these molecules, which are formed by organic processes on Earth. But this is the first ever detection of them in interstellar space, a finding the proves that these can form without the intervention of a live organism, dashing hopes that these molecules could point to life on other planets.

Indeed, this discovery suggests that organohalogens may not be useful markers of life as had been hoped by astrobiologists, who previously suggested searching for methyl chloride in the atmospheres of other planets as a possible indicator of life. This is evidence of the difficulty of finding molecules that show the existence of life beyond Earth. However, these molecules may be significant components of the material from which planets form.

Credit: B. Saxton (NRAO/AUI/NSF)

August - Home sweet home

A key milestone in the development of the observatory and improvement of living conditions for its staff was the provision of the new ALMA residence in 2017, located at the Operations Support Facilities (OSF).

Handed over on April 25, 2017, this was the last remaining construction of the entire ALMA infrastructure, designed by Finnish architects Kouvo & Partanen, and later adapted to the Chilean market by Rigotti & Simunovic Arquitectos, a Chilean architectural firm.

The buildings were designed in such a way as to ensure that the outside shape and color of this great architectural project will harmonize with the topography, environment, and landscape of the ALMA site. Given the harsh desert climate, the remote location, and the pattern of work shifts (day and night) of the ALMA staff, the Residence was designed to provide a pleasant environment for its workers. And the new residence definitely achieved this!

Credit: Pablo Carrillo - ALMA (ESO/NAOJ/NRAO)

September - Stars can also be formed in chaotically magnetized clouds

For decades, scientists believed that the magnetic field lines around a forming star were extremely powerful and orderly, warping only under extreme force and at great distance from the nascent star.

Now, a team of astronomers at ALMA has discovered a weak and surprisingly disorganized magnetic field strikingly near a young protostar dubbed Ser-emb 8, which resides about 1400 light-years from Earth in the Serpens (Serpent) star-forming region. These new observations are the most sensitive ever made of the small-scale magnetic field suffusing the region surrounding a young forming star. These observations suggest that the impact of magnetic fields on star formation is more complex than previously thought and can vary greatly from one star to the next.

Credit: NRAO/AUI/NSF; D. Berry | **Astronomical image:** ALMA (ESO/NAOJ/NRAO); P. Mocz, C. Hull, CfA.

October - Icy ring around Fomalhaut

An international team of astronomers using ALMA has made the first complete millimeter-wavelength image of the ring of dusty debris surrounding the young star Fomalhaut. This remarkably well-defined band of rubble and gas is likely the result of comets smashing together near the outer edges of a planetary system 25 light-years from Earth.

Earlier ALMA observations of Fomalhaut revealed only about one half of the debris disk. Though this first image was merely a test of ALMA's initial capabilities, it nonetheless provided tantalizing hints about the nature and possible origin of the disk.

The new ALMA observations offer a stunningly complete view of this glowing band of debris and suggest that there are chemical similarities between its icy contents and comets in our own Solar System.

Fomalhaut is a relatively nearby star system and one of only about 20 in which planets have been imaged directly. The entire system is approximately 440 million years old, or about one-tenth the age of our Solar System.

Credit: ALMA (ESO/NAOJ/NRAO), M. MacGregor | **Antennas image:** José Francisco Salgado (ESO)

November - Learning with ALMA

ALMA develops ongoing outreach activities (talks, academic workshops, exhibitions, photo exhibits, outdoor activities, etc.) to share its work and the importance of astronomy with the general public. The program promotes the science, technology, and value of ALMA and communicates these to a worldwide audience of scientists, students, media and the general public.

The Education and Public Outreach Office located in Chile coordinates the program developed in Chile with partners in North America, Europe and East Asia.

At the local level, ALMA supports a program to improve education in science and English at the Toconao public school, has helped to raise test scores for students in national standardized tests. Toconao's experience is currently being replicated to other schools in the district.

In this image, students from School E-26 in San Pedro de Atacama have fun as they learn to recognize the constellations in the dark, privileged sky of northern Chile.

Credit: Jaime Guarda - ALMA (ESO/NAOJ/NRAO)

December - A new dwarf planet? Observing DeeDee

Using ALMA, astronomers have revealed extraordinary details about a recently discovered far-flung member of our Solar System, the planetary body 2014 UZ224, more informally known as DeeDee.

Astronomers estimate that there are tens of thousands of these icy bodies in the outer Solar System. However, at about three times the current distance of Pluto from the Sun, DeeDee is the second most distant known trans-Neptunian object, surpassed only by the dwarf planet Eris.

The new ALMA data reveal, for the first time, that DeeDee is roughly 635 kilometers across, or about two-thirds the diameter of the dwarf planet Ceres, the largest member of our asteroid belt. At this size, DeeDee should have enough mass to be spherical, the criteria necessary for astronomers to consider it a dwarf planet, though it has yet to receive that official designation.

Credit: Alexandra Angelich (NRAO/AUI/NSF) | **Astronomical image:** ALMA (ESO/NAOJ/NRAO) | **Antennas image:** B. Tafreshi (ESO)

Cover photo credit: S. Otárola - ALMA (ESO/NAOJ/NRAO) | Back cover photo credit: S. Otárola - ALMA (ESO/NAOJ/NRAO) | For further information: www.almaobservatory.org

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) 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.