ALMA

ESO

NAOJ
National Astronomical Observatory of Japan

NRAO

10 years

2023 CALENDAR

ALMA.Observatory

ALMA.Radiotelescope

ALMAobs

ALMAobservatory

In search of our cosmic origins

The ALMA observatory is located in the Altiplano in northern Chile, just outside San Pedro de Atacama. The climatic and geographic conditions in the area make each sunset unique and incomparable.

In the image, a new night begins at ALMA, and although the antennas can capture signals from the Universe around the clock, a shift change draws near for nighttime observations. Under the immense Atacama sky, professionals in astronomy, engineering and a wide variety of other fields make it possible for one of the most complex and advanced machines ever built on Earth to do its job. Everyone works together around a common mission: to search for our cosmic origins.

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

Star formation in the Large Magellanic Cloud

Scientists using ALMA discovered a very particular dynamic in the star formation areas of the Large Magellanic Cloud. Despite intense stellar radiation, gravity is giving shape to a molecular cloud and, against all odds, is continually driving the formation of massive stars. 30 Doradus is a large star-forming region located 170,000 light-years away, in the heart of the famous Tarantula Nebula in the Large Magellanic Cloud. It is home to the most massive star cluster in the cosmic neighborhood, making it the perfect objective for the scientific community seeking to understand the birth and evolution of stars. The interest lies in the continuous effects of gravity and stellar feedback at work there, enormous energy released by young, massive stars that can slow down star formation.

Credit: ALMA (ESO/NAOJ/NRAO), T. Wong et al. (U. Illinois, Urbana-Champaign), S. Dagnello (NRAO/AUI/NSF)

Unforgettable postcards from Chajnantor

The ALMA antennas are located on the Chajnantor Plateau, an expanse of plains covering several kilometers at 5,000 meters above sea level. Although its climatic conditions are ideal for astronomic observation almost year-round, occasional heavy snowfall turns everything white, leaving unforgettable postcards.

In this image, taken just after a snowstorm, the ALMA antennas are still in “survival mode,” with their backs to the wind to accumulate less snow and protect themselves from inclement weather.

After every snowfall, a team of engineers and technicians must inspect each of the antennas before resuming observations. First, other teams must clean the roads as soon as possible so that this team can move closer to each of the antennas.

Credit: Pablo Carrillo – ALMA (ESO/NOAJ/NRAO)

Mandatory stopover

The Operations Support Facility (OSF) is ALMA’s base camp, located 2,900 meters above sea level and 50 km from San Pedro de Atacama. This is where most of the observatory activities take place and is a mandatory stop on the way up to the Chajnantor Plateau.

The OSF is a mini-city that operates 24/7. This includes the Residence, where ALMA employees stay overnight, eat and spend their free time. It also houses offices, laboratories, an antenna control room, a polyclinic and sports facilities, including a new covered multipurpose court soon to be inaugurated thanks to a contribution from the US National Science Foundation.

A large hangar is visible in the background of the image, where antennas are undergoing their 10-year maintenance.

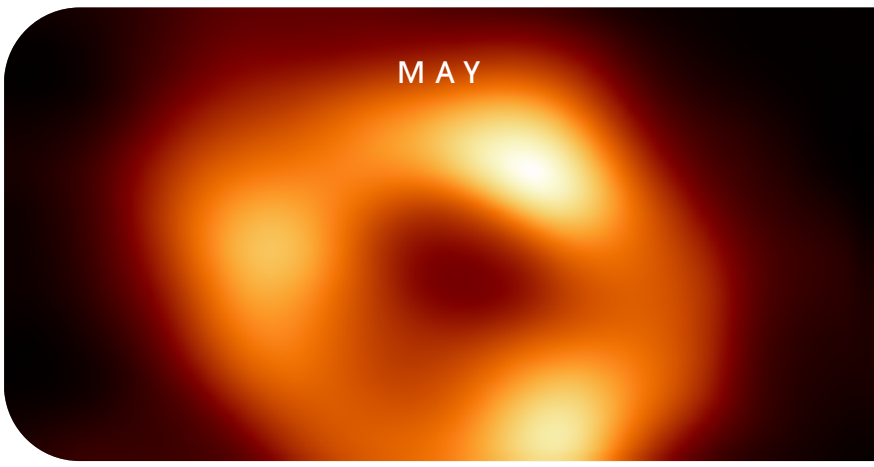
Credit: Carlos Padilla – ALMA (ESO/NAOJ/NRAO)

Observe with ALMA

The skies of northern Chile in conjunction with the exquisite technology of the international telescopes that have been installed on its territory, such as ALMA, motivate scientists from around the world to apply for observation time to develop their research and retrieve data that is unknown until now.

Everyone can apply for observation time with ALMA. However, this resource is limited and the demand is very high. There are different criteria for the selection, including technical (there is an ad-hoc commission that evaluates the technical feasibility of each proposal) and scientific criteria. A distributed peer review system is used to assess the scientific merit of each. Each member of the scientific community who submits a proposal must evaluate between 10 and 20 proposals from other colleagues under a double-blind system to guarantee objectivity. Finally, observation times are also reconciled based on how much each region contributes in keeping with the collaboration agreement with Chile, which stipulates that 10% of observation time should be allocated to Chilean institutions.

Credit: Sergio Otárola – ALMA (ESO/NAOJ/NRAO)



First image of the black hole at the heart of the Milky Way

All galaxies are believed to contain a supermassive black hole at their center, including our own, known as the Milky Way. In fact, astronomers Andrea Ghez and Reinhard Genzel earned the Nobel Prize in Physics in 2020 for proving its existence. But it was not until two years later that we were able to see an image of Sgr A*, the name given to the black hole in our galaxy, for the first time.

Although it is very large and massive, because it is located about 27,000 light-years away, its apparent size in the sky would have the same diameter as a donut on the surface of the Moon. To observe something that small, astronomers had to connect different radio telescopes around the world. They worked together to simulate a huge radio telescope almost the same size as Earth. As it is the most powerful radio telescope in the world, ALMA played a critical role in this collaboration, providing unmatched sensitivity and enabling high-quality calibration for each of the other telescopes.

Credit: EHT collaboration

A cosmic whodunit

Thanks to ALMA, a scientific team confirmed what is robbing galaxies of their star-forming gas. Galaxies are vast collections of stars, and their births, evolutions, and deaths are influenced by where they live in the Universe and how they interact with their surroundings. Specifically, galaxy clusters are among the most extreme environments in the Universe, making them particularly interesting to scientists who are studying galaxy evolution.

The Virgo Cluster is the massive cluster of galaxies closest to the Local Group, where the Milky Way resides. Its size and proximity make it easy to study from Earth. Also, it still contains a relatively large population of star-forming galaxies. This study looked at the gas reservoirs of 51 galaxies in the Virgo Cluster, revealing an environment so extreme and inhospitable that it can prevent entire galaxies from forming stars in a process known as galaxy extinction.

Credit: ALMA (ESO/NAOJ/NRAO) /S. Dagnello (NRAO)/Böhringer et al. (ROSAT All-Sky Survey)

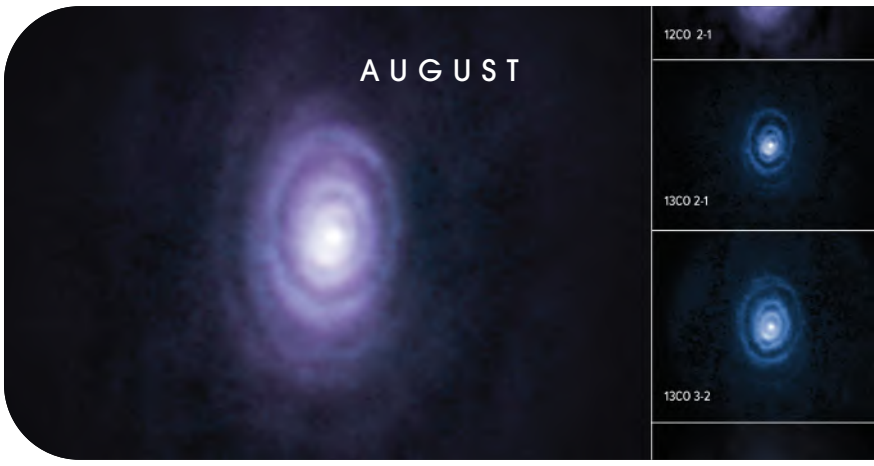
Millimetric precision despite adverse climatic conditions

The 66 antennas do not have fixed positions. ALMA has the capacity to relocate them in different positions within the Chajnantor Plateau to meet the scientific requirements for different observations. The farther apart the antennas are from each other, the greater the level of detail in the images obtained; however, their field of view will be extremely small. This antenna setting is ideal for studying small and distant objects with a great deal of precision. On the other hand, if the antennas are moved closer together, the field of view will be greater, but the image will have less detail. This is the perfect scenario for studying larger structures.

Antennas are transported from one location to another on two trucks (Otto and Lore) exclusively designed and built for ALMA. Each truck weighs 120 tons and is capable of moving one antenna (100 tons) with millimetric precision.

In this image, Lore is hard at work despite the presence of snow.

Credit: Sergio Otárola – ALMA (ESO/NAOJ/NRAO)



Six-ring spectacle

Thanks to ALMA and data analysis from the Hubble Space Telescope (HST), an astronomical team witnessed the final death throes of V Hya in unprecedented detail. They also discovered six slowly expanding rings and two hourglass-shaped structures generated by the high-speed ejection of matter.

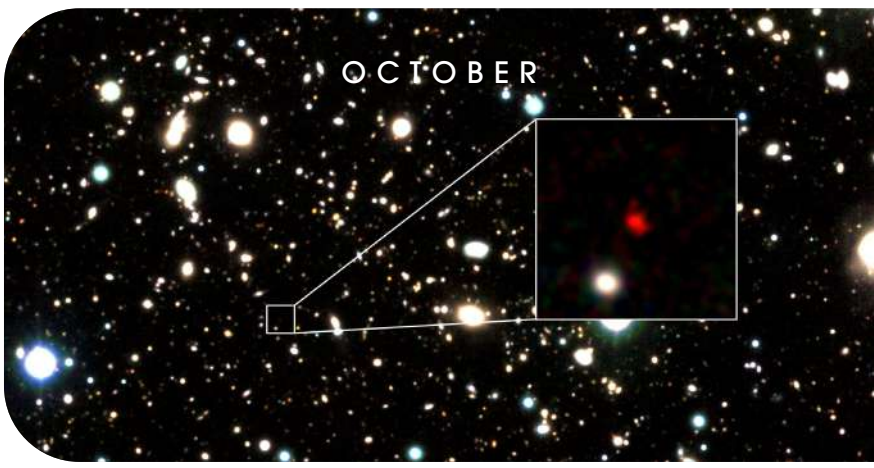
V Hya is a carbon-rich AGB star located about 1,300 light-years from Earth in the Hydra constellation. Over 90 percent of stars with a mass equal to or greater than that of the Sun end up becoming an AGB. Out of millions of such stars, V Hya has drawn scientific interest due to its massive outbursts of plasma that occur every 8.5 years and the presence of an almost invisible neighboring star that contributes to its explosive behavior. The combination of a nearby star and a hypothetical distant star would be responsible, to some extent, for the presence of the rings and the fast jets that are causing the unusual extinction of the star.

Credit: ALMA (ESO/NAOJ/NRAO) /S. Dagnello (NRAO/AUI/NSF)

Preserving a unique environment

Two of the four types of Andean camelids can be found roaming free in the territory where ALMA is located. Guanacos and vicuñas have been able to adapt to one of the inhospitable regions for life on Earth. High altitude, extreme temperatures, strong winds and intense solar radiation are some of the adverse conditions to which the fauna and flora in the area have had to adapt over thousands of years. In addition to camelids, ALMA workers frequently see vizcachas, foxes, the cardon cactus, rica-rica and llareta, animals and plants that inhabit this incredible landscape that looks more like Mars than Earth. When the observatory was given the concession to occupy this territory, one of the responsibilities and commitments it acquired was to minimize its environmental impact. In keeping with this, ALMA voluntarily submitted an Environmental Impact Study, which is overseen externally each year to ensure the preservation of this unique environment.

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



Most distant galaxy candidate

The most distant galaxy candidate to date has been discovered. It is called HD1 and is located about 13,500 million light-years away from us. Its discovery implies that bright systems like HD1 already existed 300 million years after the Big Bang. This galaxy candidate is one of the targets of the James Webb Space Telescope (JWST) launched in 2021, and if its observations confirm its exact distance, HD1 will be the most distant galaxy to our knowledge.

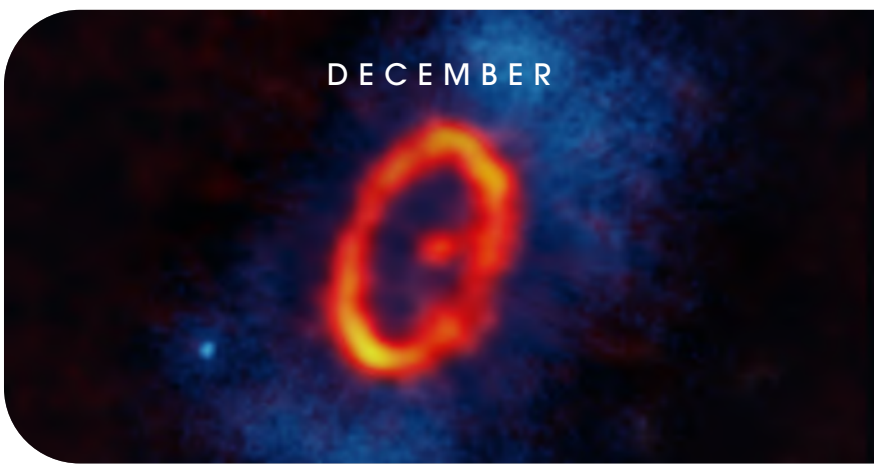
To understand how and when galaxies formed in the early Universe, astronomers search for distant galaxies. Due to its finite speed, it takes time for light from distant objects to reach Earth. The image we see of an object 1 billion light-years away implies that it had to travel that long to reach us. Therefore, studying distant galaxies lets us look back in time.

Credit: Harikane et al., NASA, ESA and P. Oesch (Yale University)

Likan Antai Territory

Before ALMA, thousands of years ago, the area was inhabited by the Likan Antai, or Atacameño people, who learned how to interact with their environment, the mountains and the desert, and they adapted to the extreme conditions prevailing in the area. Until the mid-20th century, Atacameño families occupied constructions like the ones in this image as temporary resting areas, herding their animals from one to another depending on the availability of water and food for livestock during different seasons of the year. In the municipality of San Pedro de Atacama, where ALMA is located, there are currently about 11,000 inhabitants, half of whom belong to indigenous groups. For ALMA it is essential to maintain collaborative relationships with neighboring communities and entities (such as indigenous communities, the municipality, the regional government, schools and neighborhood associations) with a special emphasis on Toconao, the town closest to the observatory.

Credit: Yerko Villalón - ALMA (ESO/NAOJ/NRAO)



Planetary formation fossils

ALMA obtained the first image of a debris disk from the nearby star HD 53143 at millimeter wavelengths, and the result is far from what was expected.

HD 53143 is about 1 billion years old, similar to the Sun, and is a star in the Carina constellation located 59.8 light-years from Earth. This star is surrounded by a debris disk thought to be similar to the one around our Sun, known as the Kuiper Belt.

New observations with ALMA's ultrasensitive receivers revealed that the debris disk of this system is, by contrast, considerably eccentric. In ring-shaped debris disks, the star is usually near the center or right at the center of the disk. In the case of eccentric disks with an elliptical shape, on the other hand, the star is located near one of the foci of the ellipsis, far from the center. This is precisely what happens in this case, something that has never been observed before. The star system could also host a second disk and at least one planet.

Credit: ALMA (ESO/NAOJ/NRAO) / M. MacGregor (U. Colorado Boulder); S. Dagnello (NRAO/AUI/NSF)

ALMA and the public

The Atacama Large Millimeter/submillimeter Array (ALMA) is an international astronomy facility funded by 21 countries in Europe, North America and East Asia, which make up the European Southern Observatory (ESO), US National Radio Astronomy Observatory (NRAO) and the National Astronomical Observatory of Japan (NAOJ) in cooperation with Chile.

For projects like ALMA to keep existing, not only is financing needed, but also qualified personnel capable of designing, developing, building and operating these incredible machines.

The dissemination of cutting-edge science that is being achieved thanks to these facilities is another of our commitments. New generations will take the reins of astronomical research, and through talks, exhibitions, social networks and countless scientific content in multiple formats (podcasts, website, videos, multimedia, etc.), we are helping to train the professionals who will work at ALMA tomorrow. Join us on this adventure!

Credito: Juan Farías – ALMA (ESO/NAOJ/NRAO)

JANUARY

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www.almaobservatory.org

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

FEBRUARY

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ALMA

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Credit: Carlos Padilla – ALMA (ESO/NAOJ/NRAO)

10 years

MARCH

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Credit: Sergio Otárola – ALMA (ESO/NAOJ/NRAO)

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Credit: EHT collaboration

MAY

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Credit: ALMA (ESO/NAOJ/NRAO) /S. Dagnello (NRAO)/Böhringer et al. (ROSAT All-Sky Survey)

JUNE

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Credit: Sergio Otárola – ALMA (ESO/NAOJ/NRAO)

JULY

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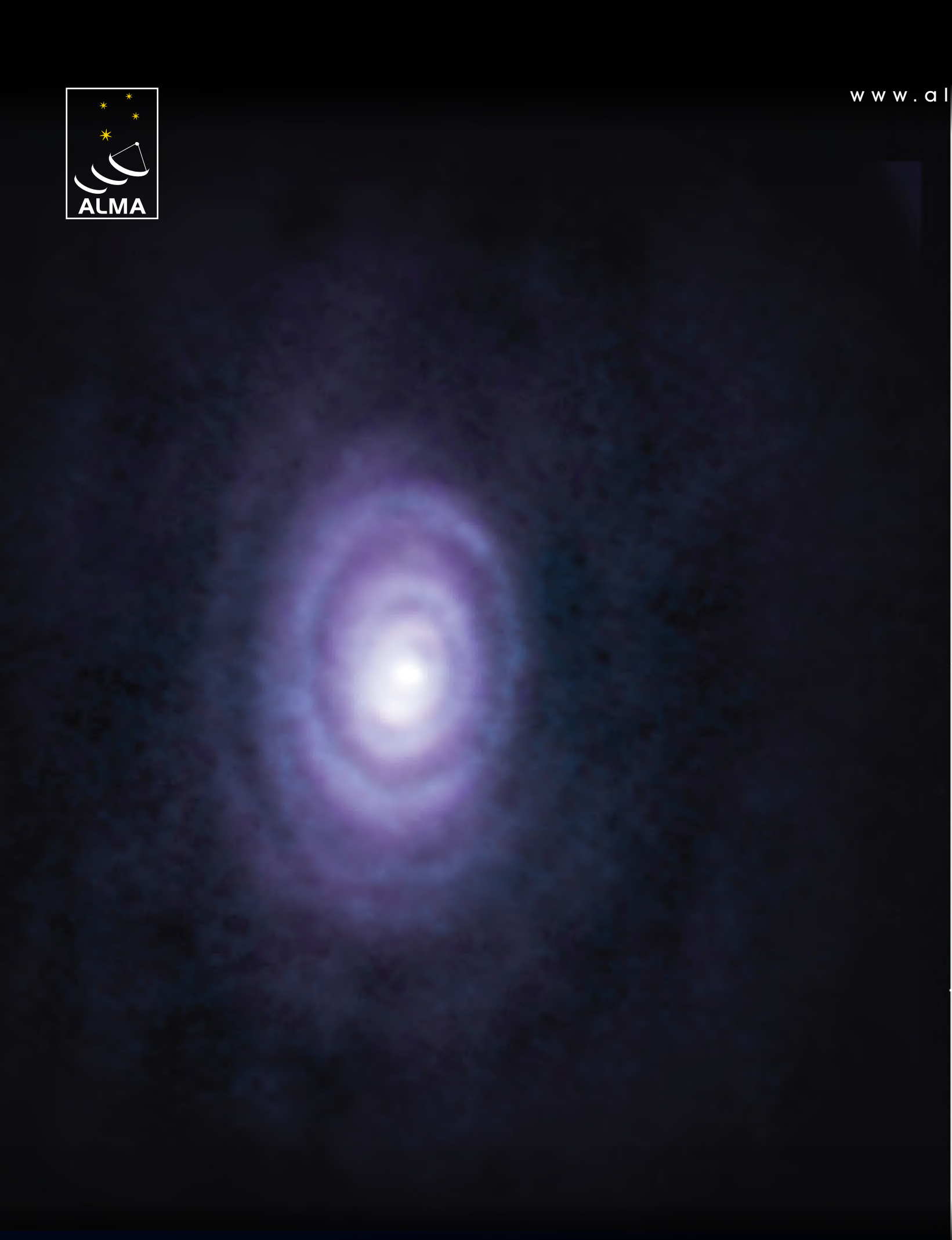

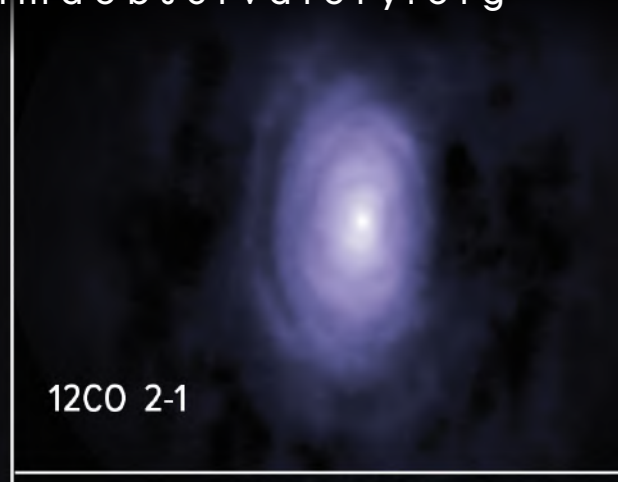

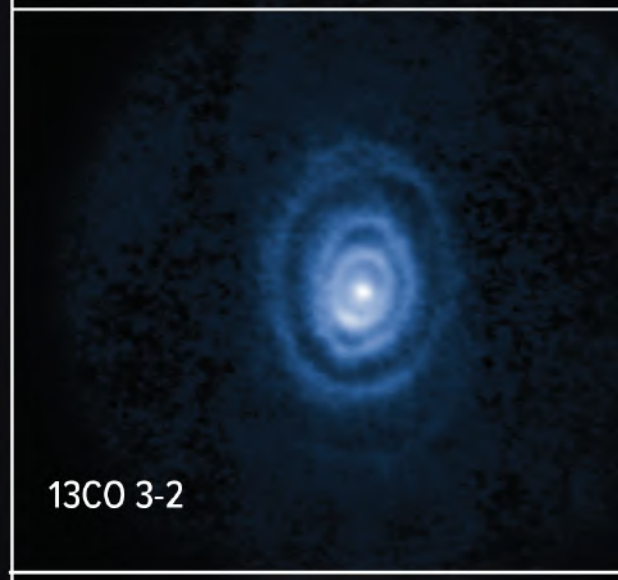

Credit: ALMA (ESO/NAOJ/NRAO) /S. Dagnello (NRAO/AUI/NSF)

AUGUST

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

SEPTEMBER

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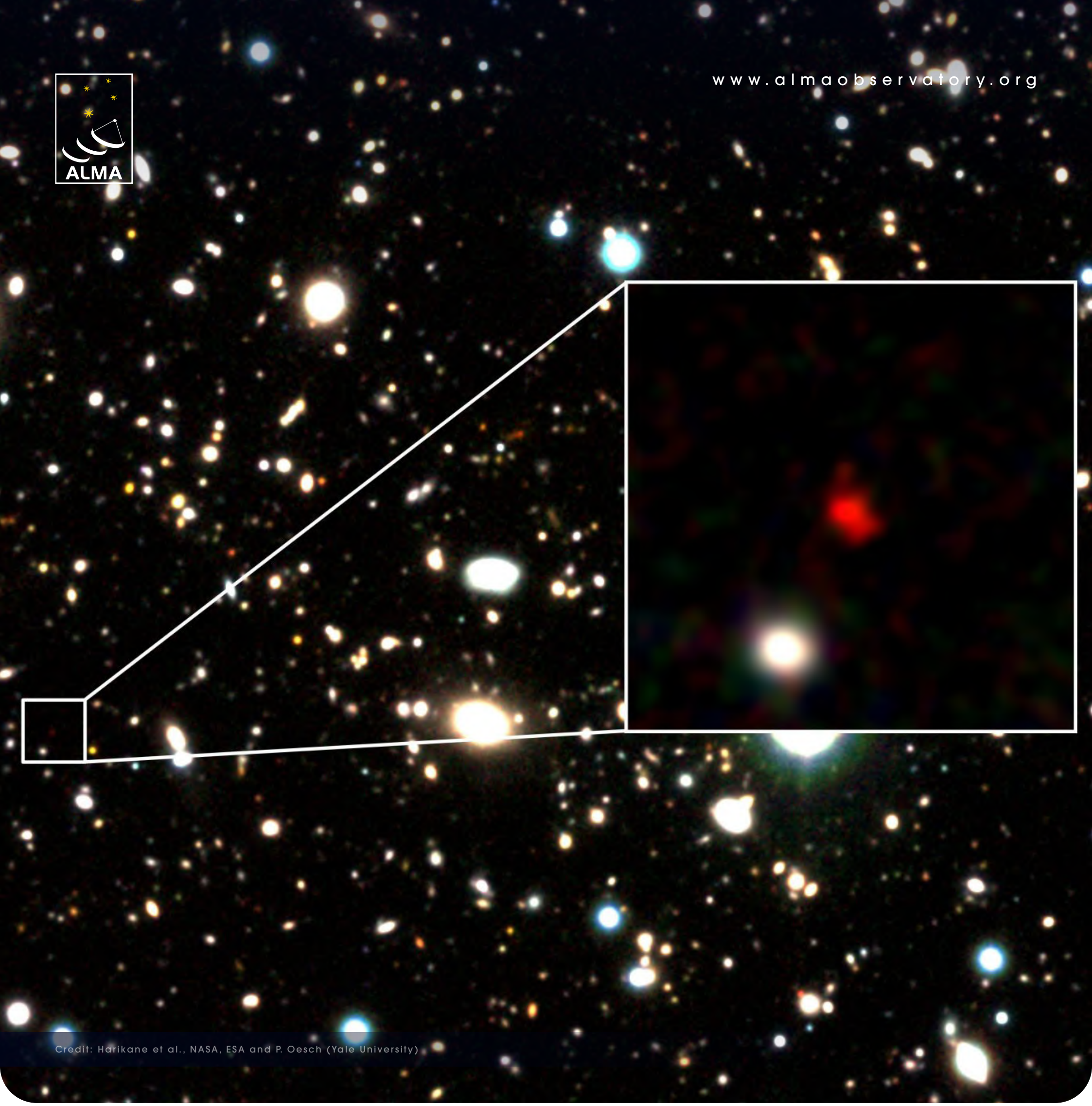

Credit: Harikane et al., NASA, ESA and P. Oesch (Yale University)

OCTOBER

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NOVEMBER

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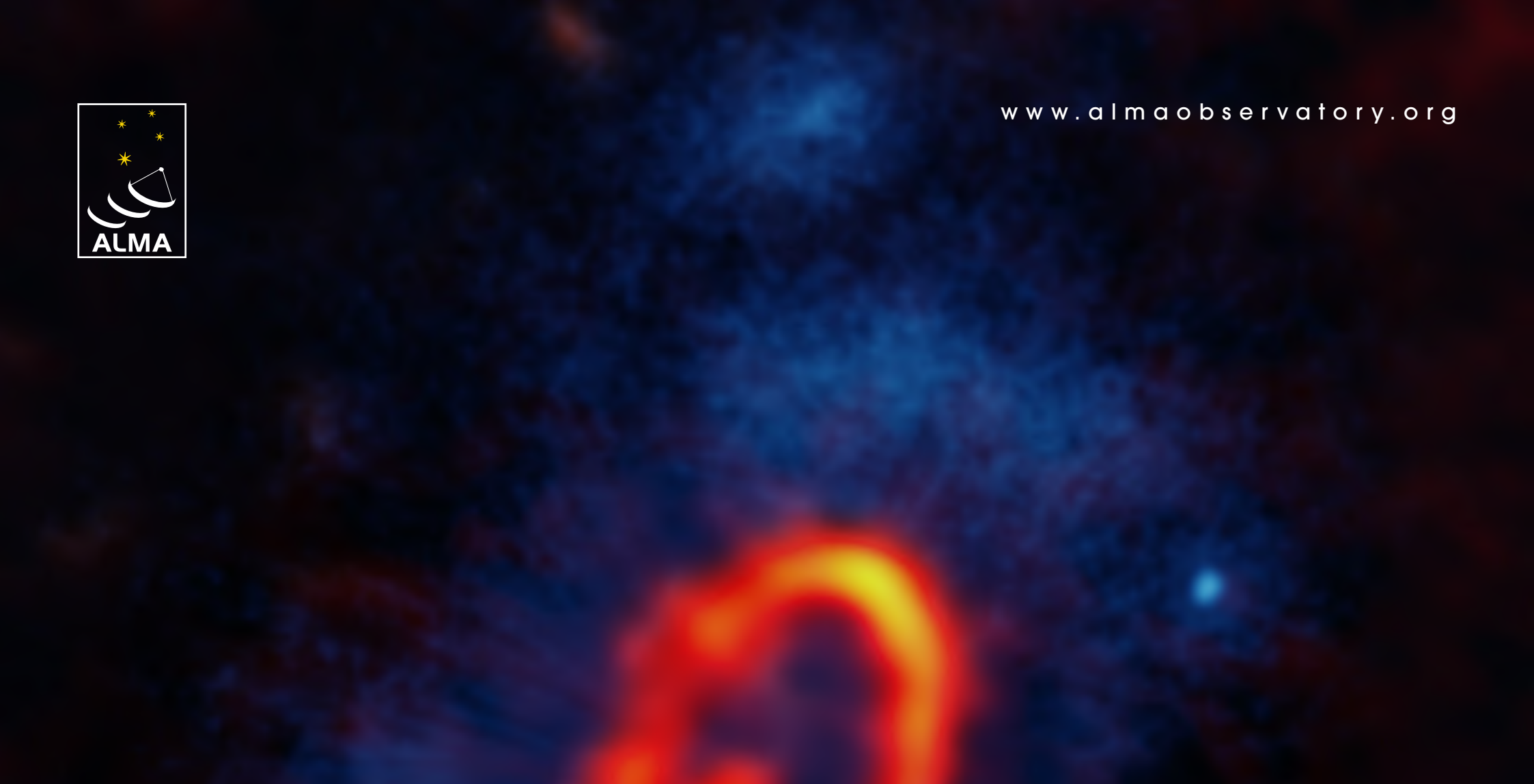

Credit: ALMA (ESO/NAOJ/NRAO) / M. MacGregor (U. Colorado Boulder); S. Dagnello (NRAO/AUI/NSF)

DECEMBER

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Credit: Juan Farías – 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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