2020 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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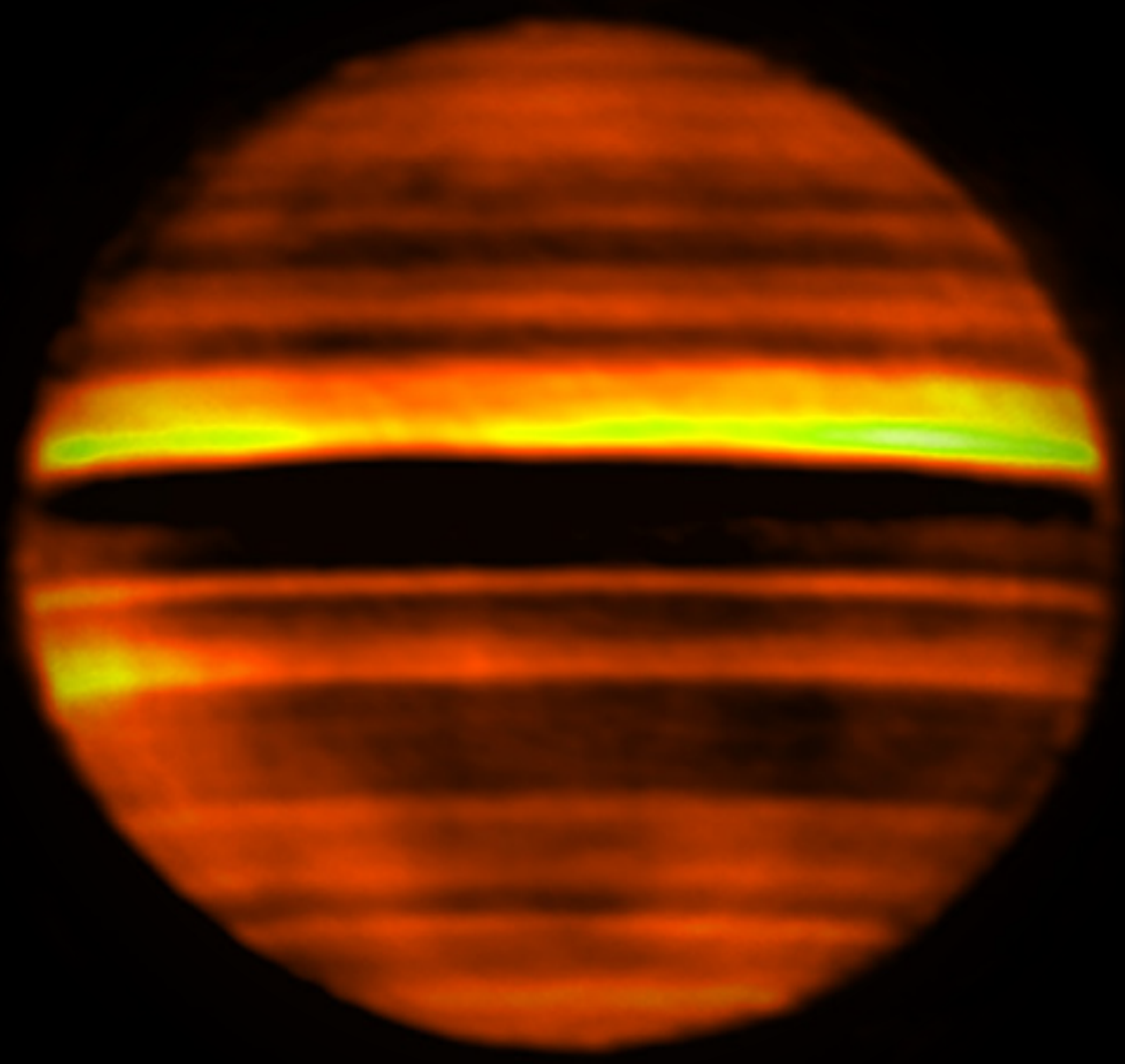

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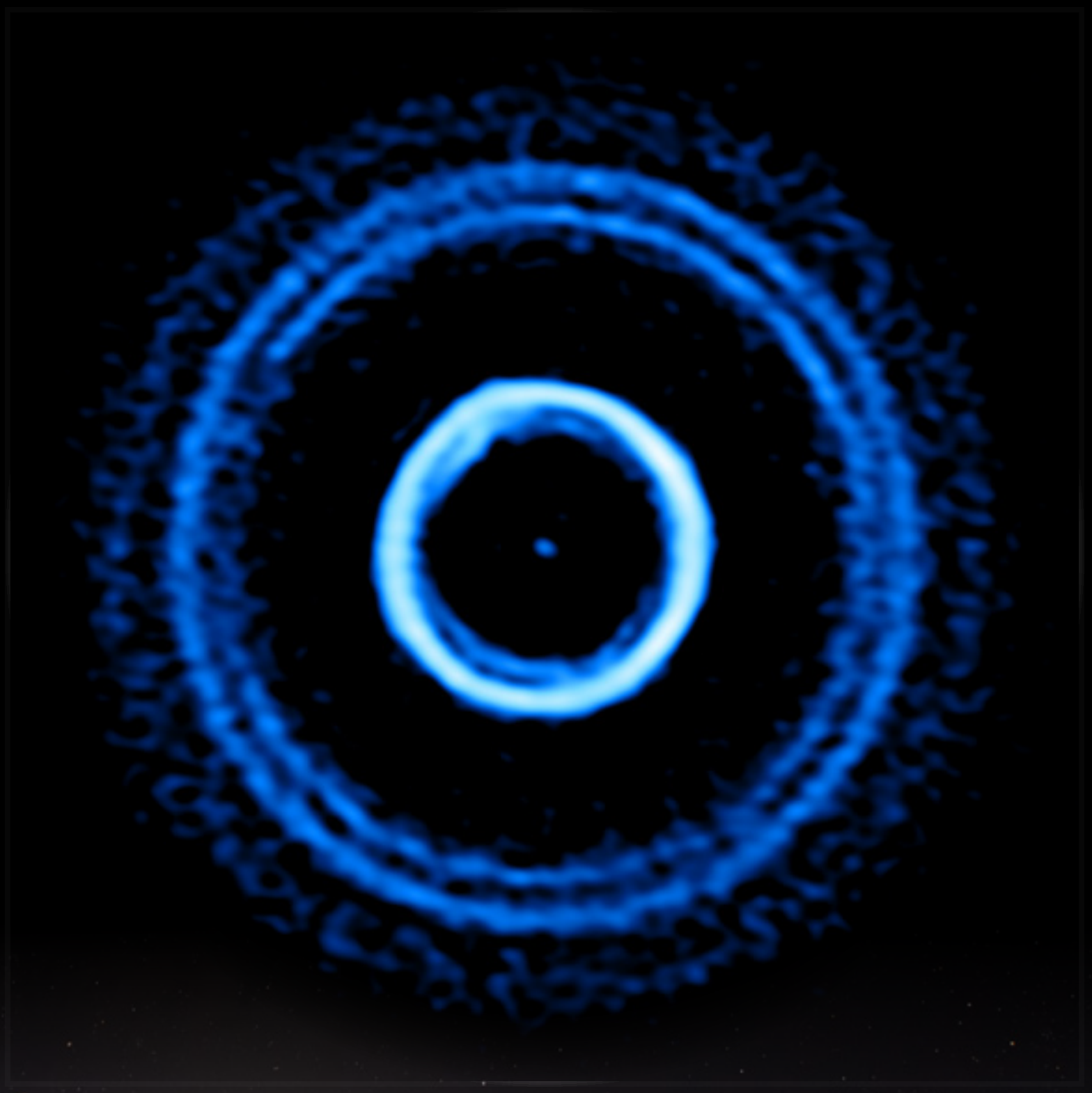

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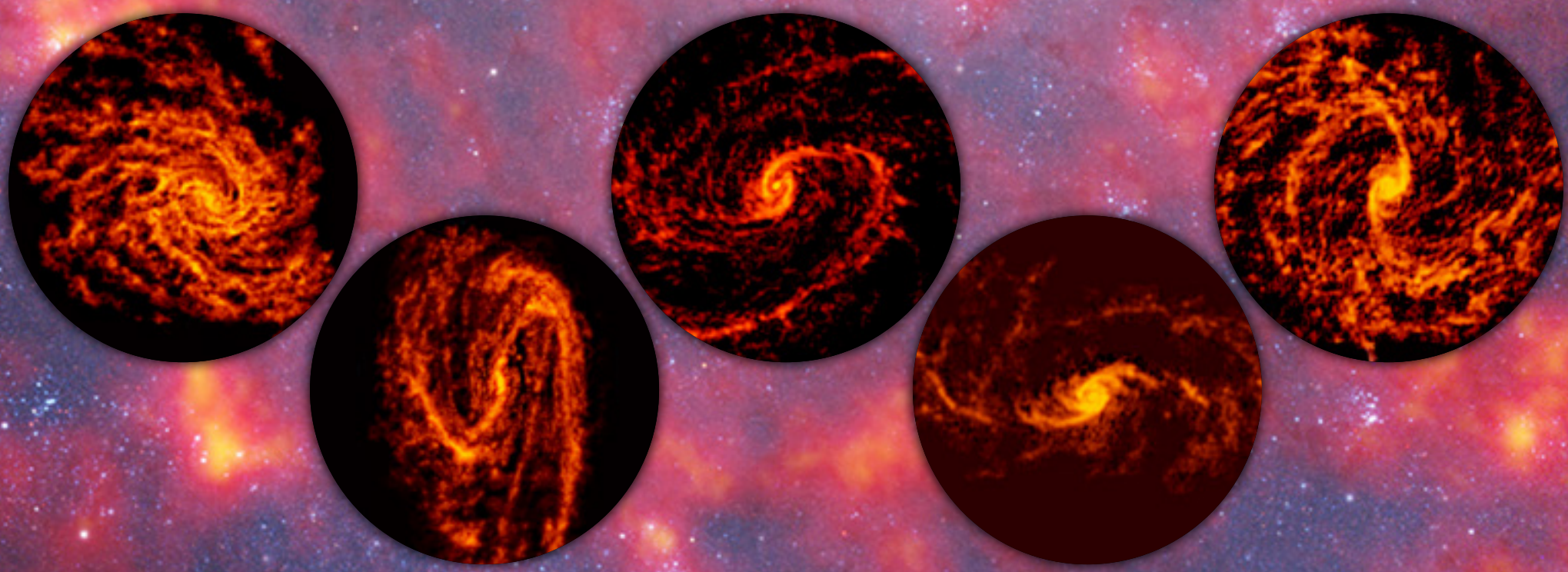

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SEPTEMBER

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OCTOBER

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NOVEMBER

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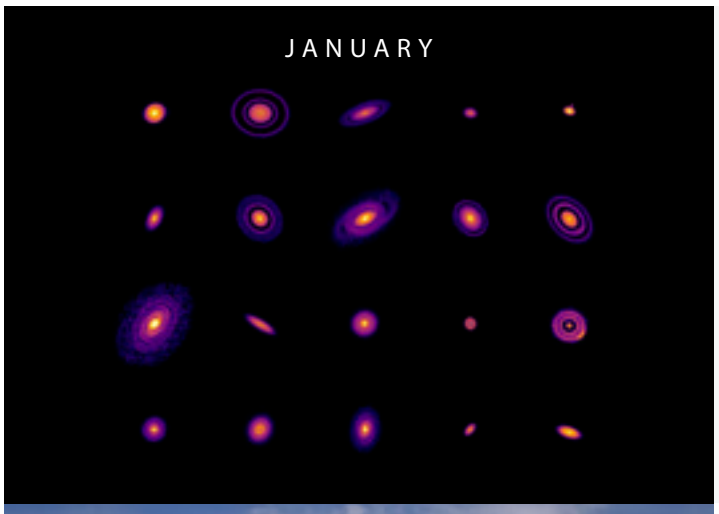


ALMA Provides Unprecedented Views of the Birth of Planets

Astronomers have already cataloged more than 4,000 exoplanets, which are planets that don't belong to the Solar System. Though we have learned much about these, there is still much we do not know about planet formation. To help answer these and other questions about the birth of planets, astronomers used ALMA to conduct one of the most detailed maps ever of protoplanetary disks, the planet-forming gas and dust belts around young stars.

This mapping was one of the Large Programs of ALMA known as the *Disk Substructures at High Angular Resolution Project* (DSHARP). It has yielded stunning images of 20 nearby protoplanetary disks and has provided new data on their features and formation.

According to the astronomers, the larger planets, likely similar in size and composition to Saturn, form much faster than current theory would indicate, and very far from their host star.

Such precocious formation could also help explain how rocky, Earth-size planets are able to evolve and grow, surviving their presumed self-destructive adolescence.

Credit: ALMA (ESO/NAOJ/NRAO), S. Andrews et al.; N. Lira.

Extreme Climate on the Chajnantor Plateau

Climatic conditions are extreme at 5,000 meters above sea level in the Andean altiplano. Temperatures can drop below -20ºC and if precipitations occur, they fall as snow, not rain. When this occurs, ALMA must pause its observations of the Universe, and place its antennas in the 'survival' position, i.e., facing away from the wind. Once the storm has passed, like sunflowers, they are moved to face the Sun to quickly melt any snow that might have built up on their discs. Astronomical observations can only resume once engineers and technicians from the antenna maintenance group have conducted a visual inspection of the entire array.

Operating an astronomical observatory as complex as ALMA in the Chajnantor Plateau requires workers from around the world to work with maximum care to prevent accidents, use resources efficiently and produce scientific data of excellent quality. ALMA is a global adventure at the forefront of knowledge in search of our cosmic origins.

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

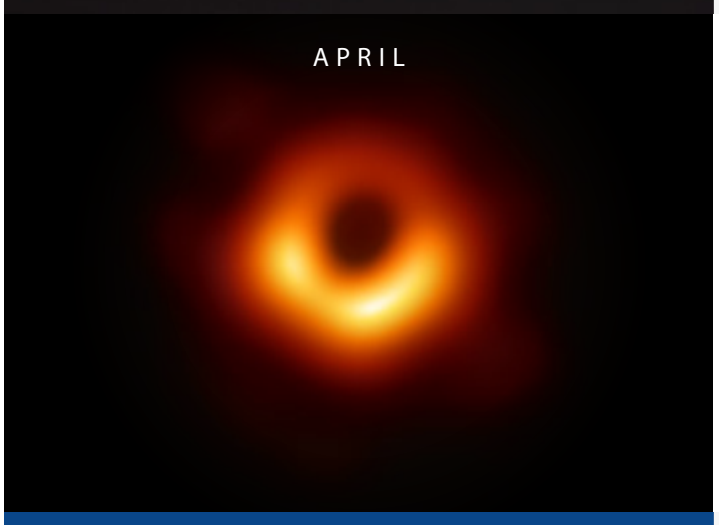
SgrA*, the Galactic Center

ALMA's privileged location not only ensures a dry and stable climate. Due to its location north of the Tropic of Capricorn, it has a direct line of sight with the Center of the Milky Way during at least 5 months of the year. In addition to allowing us to take stunning photos like this one, its unique location also gives our astronomers an unparalleled opportunity to study one of the most attractive regions of the Universe.

Now, a decade after the first antenna was brought to the Chajnantor Plateau, these antennas are beginning to require full maintenance. They are transported, one by one, to the Operations Support Facility (OSF), which is fully equipped to return them to perfect operating conditions.

The DV-02 antenna can be seen at the OSF in the foreground of this image, under the beauty of the center of the Milky Way, as it awaits its return to once again examine the sky.

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



1st Image of a Black Hole

A year ago, on April 10, 2019, five press conferences around the world simultaneously revealed the first image of a black hole. Over 200 scientists from different countries united around the Event Horizon Telescope (EHT) collaboration, linking eight radio telescopes around the globe to form an Earth-sized virtual telescope. With unprecedented resolution, they were able to observe the supermassive black hole located at the center of the nearby galaxy M87.

ALMA's geographical location and its large collection surface gave it a key role in achieving this goal, which was the result of decades of joint efforts. The 347 members of this collaboration were recipients of the prestigious 2020 Breakthrough Prize in Fundamental Physics. And the Senate of Chile recognized the work of ALMA scientists, awarding them a Silver Medal.

Black holes are cosmic objects characterized by their enormous mass in a very compact region, which has a gravitational effect on their surroundings, bending space-time and superheating the surrounding matter. The EHT provides a new method to study these extreme objects in the Universe and confirm predictions made over 100 years ago by Albert Einstein.

Credit: EHT Collaboration

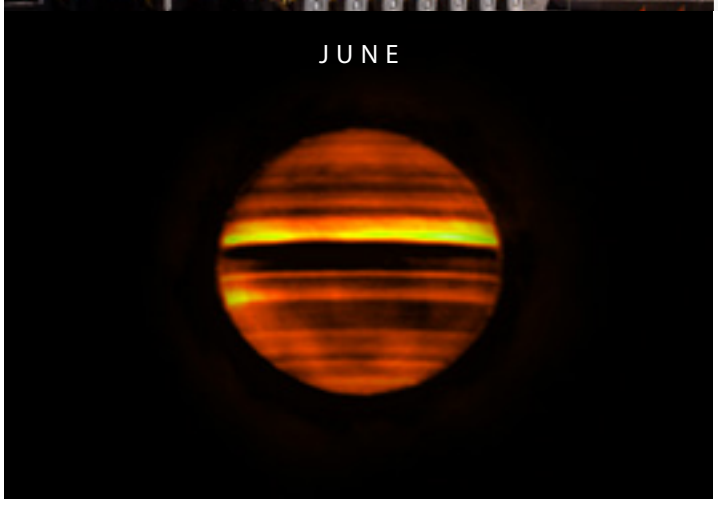
Titans of Astronomy

Otto (at the forefront) and Lore (in the background) are transporters that have been designed specifically to complete the delicate mission of relocating the observatory's antennas. This is a crucial role, as one of the characteristics of ALMA is that it is able to modify the distance between its antennas, thereby covering the different observation needs of the astronomical community.

These trucks have independent traction and rotation on their 28 wheels, they weigh 130 tons and are equipped with two diesel engines of approximately 700 horsepower (500 kW). This gives them enough power to move the antennas at a speed of 5 kilometers per hour, while keeping them connected to a power source to prevent them from losing the cold temperature in their receptors (-269º Celsius or 4º Kelvin).

Because their unique design is not found anywhere else in the world, ALMA mechanics have had to learn to operate, maintain and repair them. During antenna loading and unloading processes, the transporter operator must exit the vehicle and operate it by remote control, watching over the process from nearby and undertaking this with millimetric precision.

Credit: Juan Carlos Rojas - ALMA (ESO/NAOJ/NRAO)



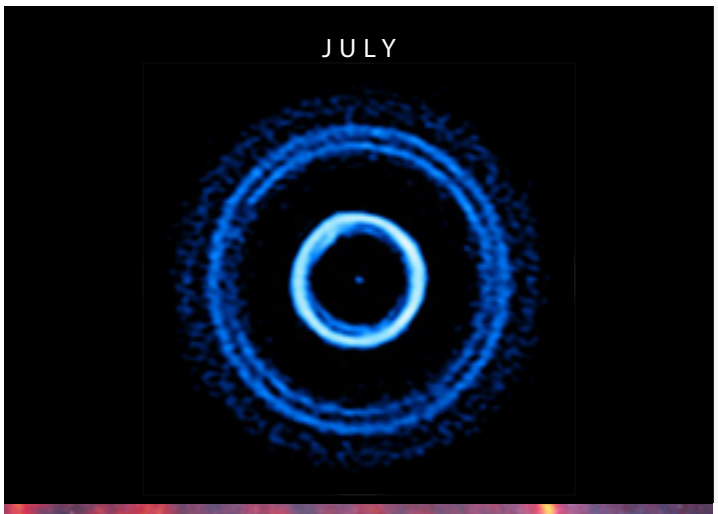
Alma Shows What's Inside Jupiter's Storms

Swirling clouds, big colorful belts, giant storms. The beautiful and turbulent atmosphere of Jupiter has been showcased many times. But what is going on below its clouds? What is causing the many storms and eruptions that we see on the 'surface' of this planet? To understand this, visible light is not enough. We need to observe Jupiter using radio waves.

A few days after amateur astronomers observed an eruption in Jupiter's South Equatorial Belt, new images taken with ALMA in January 2017 provide a unique view of its atmosphere down to 50 kilometers below its cloud deck.

The atmosphere of this giant planet is made out of mostly hydrogen and helium, together with trace gases of methane, ammonia, hydrosulfide, and water. The top-most cloud layer is made up of ammonia ice. Below that is a layer of solid ammonia hydrosulfide particles, and deeper still, around 80 kilometers below the upper cloud deck, there is a layer of liquid water. The upper clouds form the distinctive brown belts and white zones seen from Earth.

Credit: ALMA (ESO/NAOJ/NRAO), I. de Pater et al.; NRAO/AUI NSF, S. Dagnello.



ALMA Reveals Migrating Planet in Protoplanetary Disk

A new high-resolution image from ALMA features a protoplanetary disk with an isolated outer region composed of an intricate system of thin rings and gaps, instead of the wide and smooth ring expected for these disks. The isolation zone of these never seen before structures allowed a research team to propose the following explanation: a migrating planet ten times the mass of Earth sculpting the dust particles into narrow rings.

ALMA has seen a plethora of rings and gaps in almost all the protoplanetary disks it has studied, yet the origins of these structures remain a matter of debate. As the quality of the observations increases, the ringed structures grow in number and complexity, challenging a simple interpretation of this phenomenon. These new ALMA observations of HD169142, a protoplanetary disk 370 light-years away from Earth, in Sagittarius, explained the seemingly complex architecture of protoplanetary ring systems with the presence of a single low-mass planet.

Credit: N. Lira - ALMA (ESO/NAOJ/NRAO); S. Pérez - USACH/U.Chile.

What do 100,000 Star Factories Tell Us about Star Formation across the Universe?

Galaxies come in a wide variety of shapes and sizes. Some of the most significant differences relate to where and how they form new stars. Compelling research to explain these differences has been elusive, but the luck of the astronomers is changing. An unprecedented campaign conducted by ALMA, which amassed a total of 750 hours of observations covering 74 nearby spiral galaxies, is unraveling the relationship between star-forming clouds and their host galaxies.

An ALMA research project, known as PHANGS (Physics at High Angular Resolution in Nearby Galaxies), delves into this question with far greater precision and detail than ever before by measuring the demographic and individual characteristics of stellar nurseries spread throughout numerous galaxies.

Credit: ALMA (ESO/NAOJ/NRAO); NRAO/AUI/NSF; B. Saxton

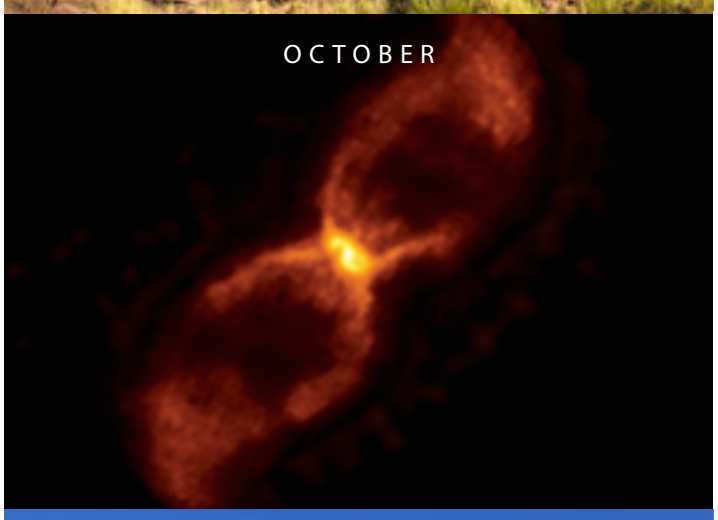
A Wild Ecosystem

The unique location of ALMA is home to a surprisingly complex ecosystem with diverse flora and fauna. Species found in the observatory's concession area include Andean foxes, vicuñas, vizcachas, wild donkeys and caranchos. Typical altiplano plants in the area include the rika-rika, llareta, and the giant cardon cactus (Echinopsis atacamensis), which can measure up to 7 meters high.

This vicuña forms part of one of the several vicuña families that live near ALMA and move freely about the altiplano.

For ALMA, environmental preservation is paramount, and we continually strive to generate as little impact as possible to the ecosystem. We also conduct data surveys and studies on the health of the species that share this incredible adventure with us.

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



So it Wasn't a Nova After All

In July of 1670, astronomers on Earth thought they had observed a "new star," or nova, in the constellation Cygnus. They saw a bright pinprick of light, which then faded, reappeared, and then disappeared into the dark sky.

Modern astronomers studying the remains of this cosmic event initially thought it heralded the merging of two stars on the same evolutionary path as our Sun.

However, new observations with ALMA point to a more intriguing explanation. By studying the debris from this explosion, which takes the form of dual rings of dust and gas resembling an hourglass with a compact central object, the researchers concluded that this structure is the result of a white dwarf (the elderly remains of a star like the Sun) colliding with a brown dwarf (a failed star without the mass to sustain nuclear fusion). This collision, witnessed on Earth in 1670 and dubbed Novasub Capite Cygni (a New Star below the Head of the Swan), is now known as CK Vulpeculae.

Credit: ALMA (ESO/NAOJ/NRAO) / S. P. S. Eyres | **Image antennas:** Juan Carlos Rojas - ALMA (ESO/NAOJ/NRAO)

Eclipse from Toconao and San Pedro de Atacama

Everyone wanted to be ready to safely view the solar eclipse on July 2 last year. In preparation for this, the ALMA Observatory handed out solar eclipse glasses to students and teachers in San Pedro de Atacama's schools: Escuela E-26, Liceo Likanantai and the Toconao Educational Complex. In a gesture of appreciation, the San Pedro de Atacama schoolchildren reenacted an allegory about the creation of the Sun and the Moon, which included a specific explanation about what produces an eclipse.

The teachers also did their part. On the day of the eclipse, they presented experiments they had learned in a workshop conducted by ALMA in response to questions such as: How can we determine the distance between the Moon and the Earth? How can we explain the occurrence of eclipses? How can we observe them safely? Elementary and high school teachers from Toconao, San Pedro de Atacama, Calama, and from as far as Antofagasta, participated in the workshop and learned how to use these tools.

We also wanted this to be an inclusive eclipse. ALMA handed out special materials for blind people: A book with tactile graphs and Braille to illustrate the stages of the eclipse, a device that transforms light into sound (allowing blind children to "hear the eclipse" in real time) and a kit of galaxies printed in 3D.

Credit: ALMA (ESO/NAOJ/NRAO)

2019 Solar Eclipse Image from ALMA

The Total Solar Eclipse of July 2, 2019, in Chile was partially visible from the ALMA observatory with 76% of the Sun covered by the Moon.

The Array Operations Site (AOS) faced adverse climatic conditions on the day of the eclipse: Snow, high winds up to more than 10 meters per second, and cloudy skies posed challenges to observing the phenomenon.

Against all the odds, the Department of Engineering managed to recover one of the antennas affected by snowfall on the Chajnantor Plateau just in time. This antenna was able to observe the Sun in great detail. 27 images of the eclipse of the Moon partially blocking our star were taken to create a short video of the phenomenon.

However, winds more than 15 meters per second forced observations to stop before the end of the eclipse.

Credit: José Pinto (ALMA), Masumi Shimojo (NAOJ), Antonio Hales (NRAO/ALMA), Akihiko Hirota (NAOJ/ALMA); ALMA (ESO/NAOJ/NRAO).

Cover photo credits: Sergio Otárola - ALMA (ESO/NAOJ/NRAO). **Back cover photo credits:** Juan Carlos Rojas - ALMA (ESO/NAOJ/NRAO) | Additional 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.