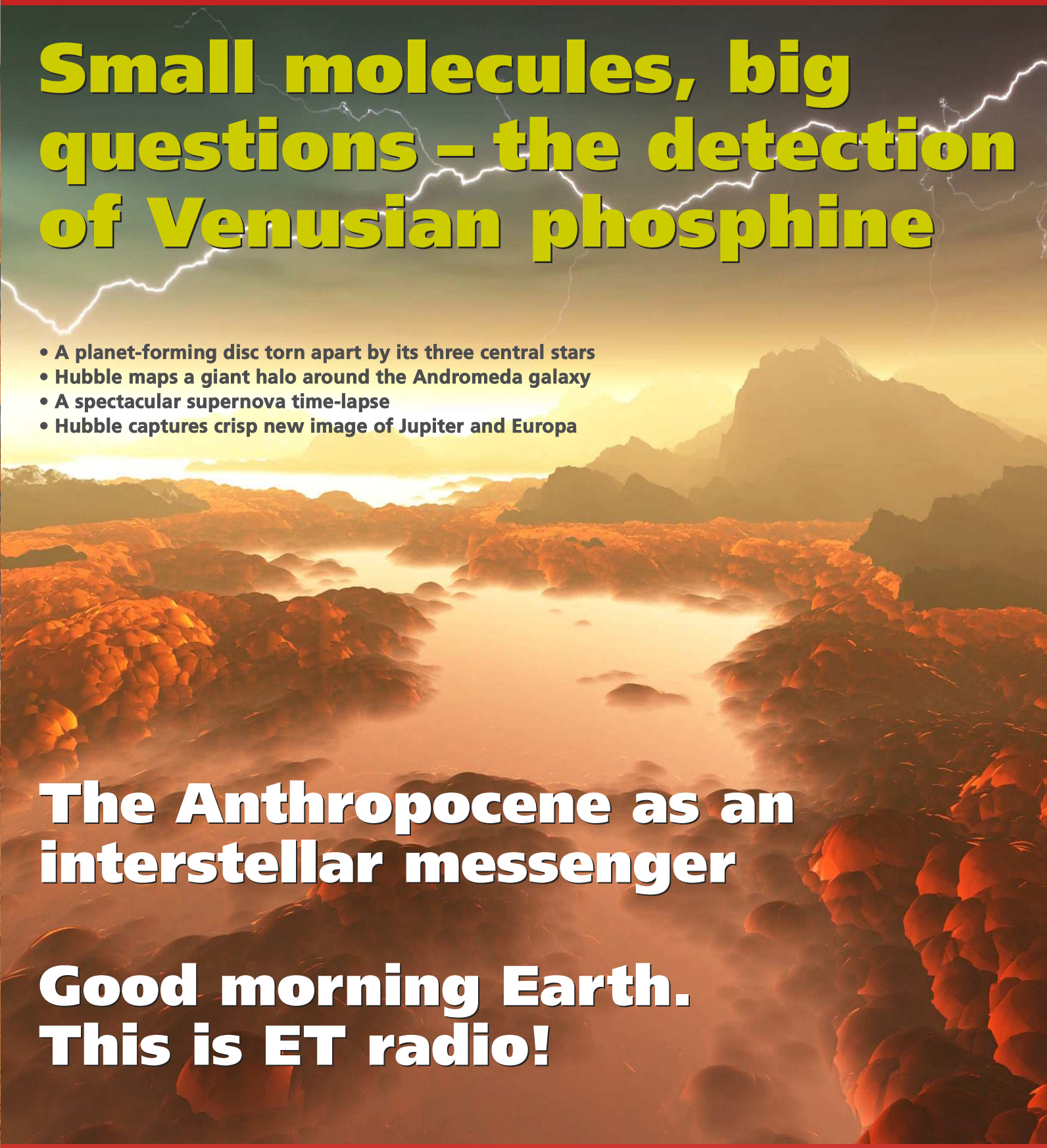
THE FREE MULTIMEDIA MAGAZINE THAT KEEPS YOU UPDATED ON WHAT IS HAPPENING IN SPACE

FREE ASTRONOMY magazine

Bi-monthly magazine of scientific and technical information ✶ November-December 2020



Small molecules, big questions – the detection of Venusian phosphine

- A planet-forming disc torn apart by its three central stars
- Hubble maps a giant halo around the Andromeda galaxy
- A spectacular supernova time-lapse
- Hubble captures crisp new image of Jupiter and Europa

The Anthropocene as an interstellar messenger

Good morning Earth. This is ET radio!

www.astropublishing.com ✶ www.facebook.com/astropublishing ✶ info@astropublishing.com

ESO Calendar 2021 Now Available

https://www.eso.org/public/usa/shop/product/calendar_2021/

The 2021 edition of one of our most popular products, the ESO Calendar, is now available and can be purchased from the online ESOshop and in the ESO Supernova Planetarium & Visitor Centre.

The calendar's cover features a spectacular starscape around the relatively unknown central object, Gum 15, a nebula in which stars are being born. The image also features one of the closest supernova remnants to Earth, which exploded between 11,000 and 12,300 years ago and is located 800 light-years away from our cosmic home.

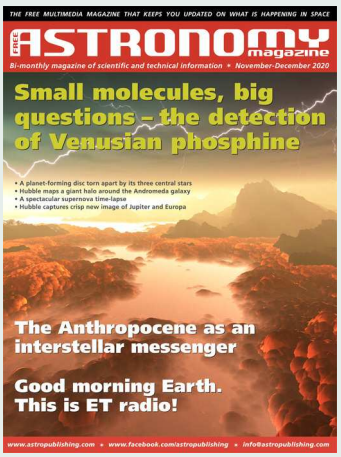
For the month of March, the bright band of the Milky Way arcs above the ALMA antennas on the Chajnantor plateau. One of the closest stellar nurseries to Earth, the Orion Nebula, is the chosen image for July and the massive 3-tonne blank for the Extremely Large Telescope's (ELT) secondary mirror is the star of September. Finally, in December the viewer will feel they are speeding towards the centre of our galaxy, thanks to a clever photographic technique used on an observation of the Milky Way. These are just a few highlights, we invite you to view the individual pages of the ESO Calendar 2021 here.

The calendar has a total of 14 pages, and is available for 9.50 EUR in the ESOshop — but stock is limited so don't delay!

FREE ASTRONOMY magazine

BI-MONTHLY MAGAZINE OF SCIENTIFIC AND TECHNICAL INFORMATION FREELY AVAILABLE THROUGH THE INTERNET

November-December 2020



English edition of the magazine

ASTROFILO

Editor in chief
Michele Ferrara

Scientific advisor
Prof. Enrico Maria Corsini

Publisher
Astro Publishing di Pirlo L.
Via Bonomelli, 106
25049 Iseo - BS - ITALY
email info@astropublishing.com

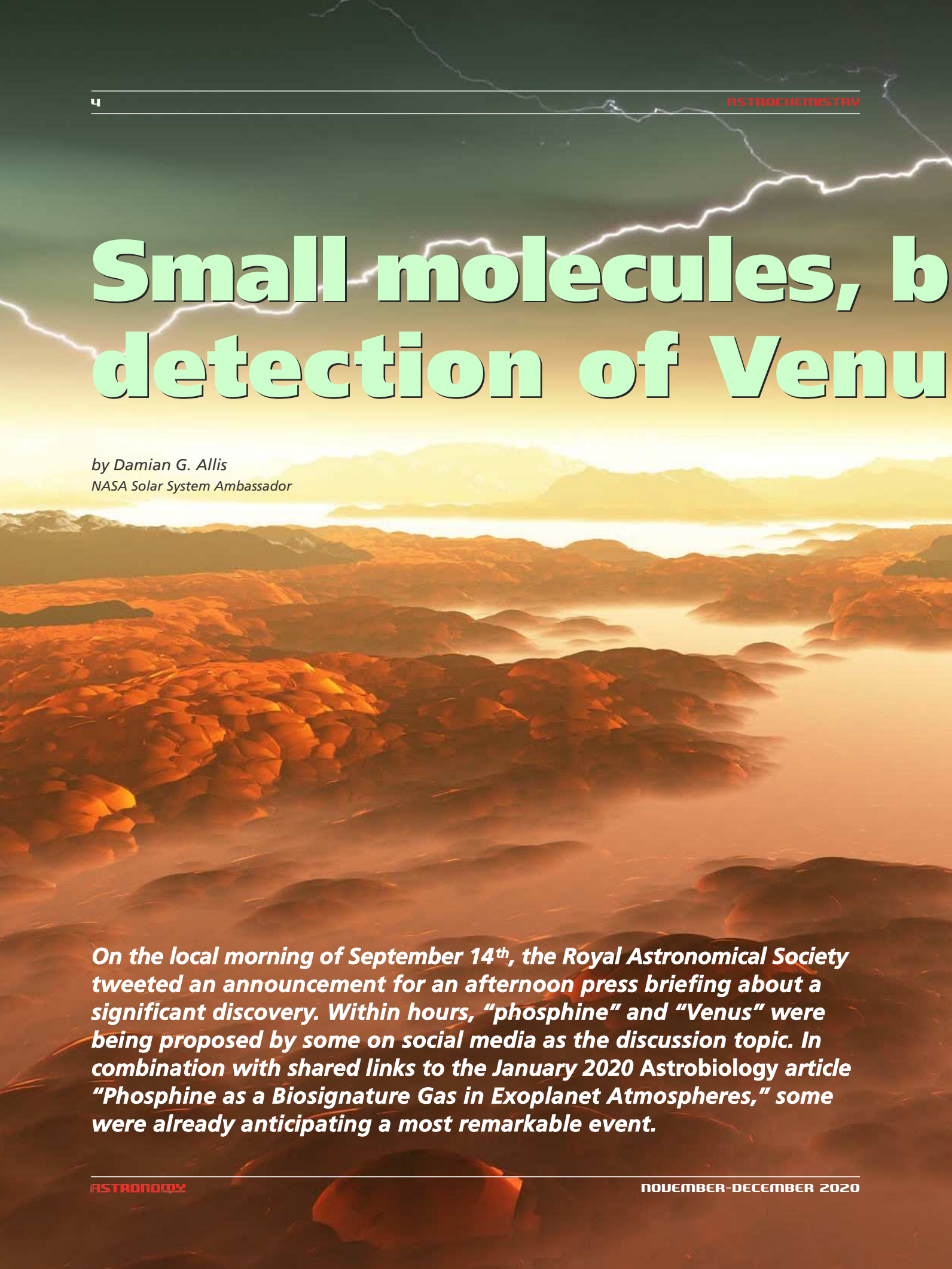
Internet Service Provider
Aruba S.p.A.
Via San Clemente, 53
24036 Ponte San Pietro - BG - ITALY

Advertising - Administration
Astro Publishing di Pirlo L.
Via Bonomelli, 106
25049 Iseo - BS - ITALY
email admin@astropublishing.com

SUMMARY

Small molecules, b
detection of Venu

by Damian G. Allis
NASA Solar System Ambassador

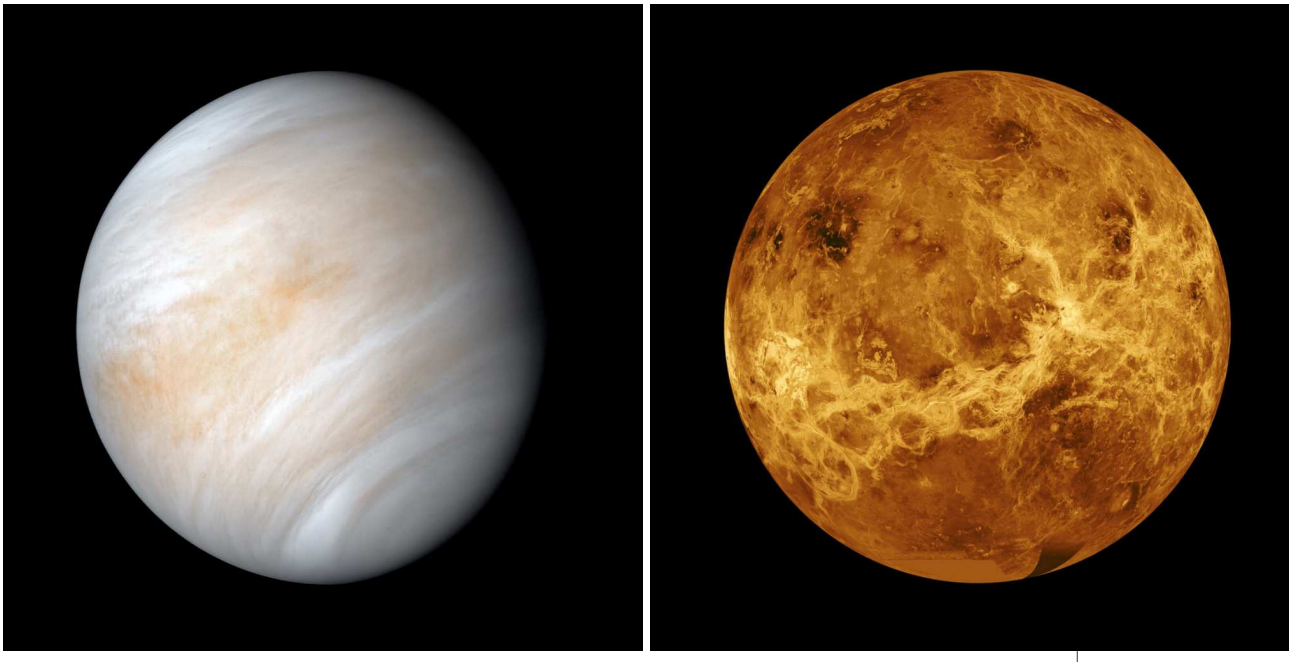


On the local morning of September 14th, the Royal Astronomical Society tweeted an announcement for an afternoon press briefing about a significant discovery. Within hours, "phosphine" and "Venus" were being proposed by some on social media as the discussion topic. In combination with shared links to the January 2020 Astrobiology article "Phosphine as a Biosignature Gas in Exoplanet Atmospheres," some were already anticipating a most remarkable event.

ig questions – the sian phosphine

An artist's vision of electrical discharges in the hot sky of Venus. Lightning and volcanism could be the origin of the recently discovered phosphine in the planet's atmosphere. [J. Peter]

An international team from the UK, USA, and Japan, led by Prof. Jane Greaves of Cardiff University, released their open access article "Phosphine gas in the cloud decks of Venus" in *Nature Astronomy* as the press briefing was taking place. The cautious excitement of Greaves, Dr. Anita Richards (Jodrell Bank Centre for Astrophysics), and Dr. William Bains and Prof. Sara Seager (MIT) over bringing such a potentially groundbreaking and multi-disciplinary discovery to fruition was obvious to all in attendance. No topic in science generates more speculation than extraterrestrial life, and the discoverers will go down in history for that achievement – this would clearly be a milestone as the names "Gagarin" and "Armstrong/Aldrin/Collins" conjure. One assumes the most benevolent intentions of such a briefing, especially with the presenters stating that their work is of a mo-

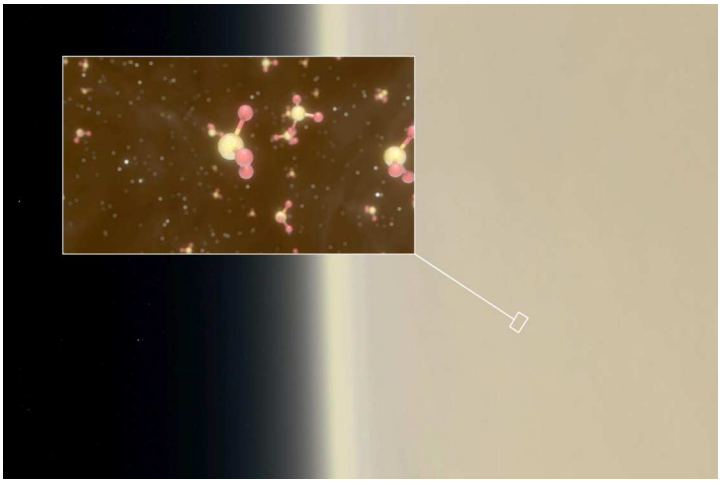


lecular detection and an interpretation in the absence of any known non-biological explanations. That said, one can only imagine the instinct to be the first to make such a discovery, however preliminary, known to the world as soon as possible.

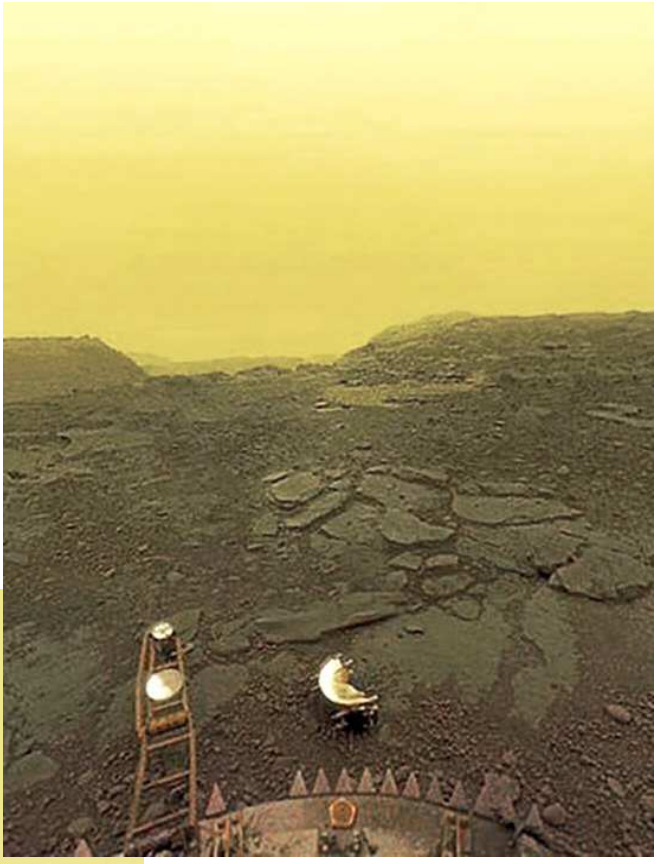
What has followed is a story of measurement, interpretation, reserved speculation, and controversy – not over the discovery of phosphine, but over its indication as a possible biological marker, which has driven discussion beyond just the astronomical community. What is most clear is how little we still know about our own solar system, as a simple molecule can lead to heated debate because of our incomplete understanding of the chemistry and geology of our nearest planetary neighbors.

What we know and do not *yet* know about the production of phosphine, PH_3, on Venus are central to the past few weeks of speculation. On Earth, phosphine can be produced by lightning and volcanism, both common on Venus. That said, the atmospheric and geochemical routes to phosphine could only account for a fraction of the amount detected based on our current understanding of both phenomena. The possible explanation put forth by the authors applies the predominant method of phosphine production on Earth – biochemical processes in low-oxygen conditions.

As is obvious from the many design features of the few successful Venera and Pio-

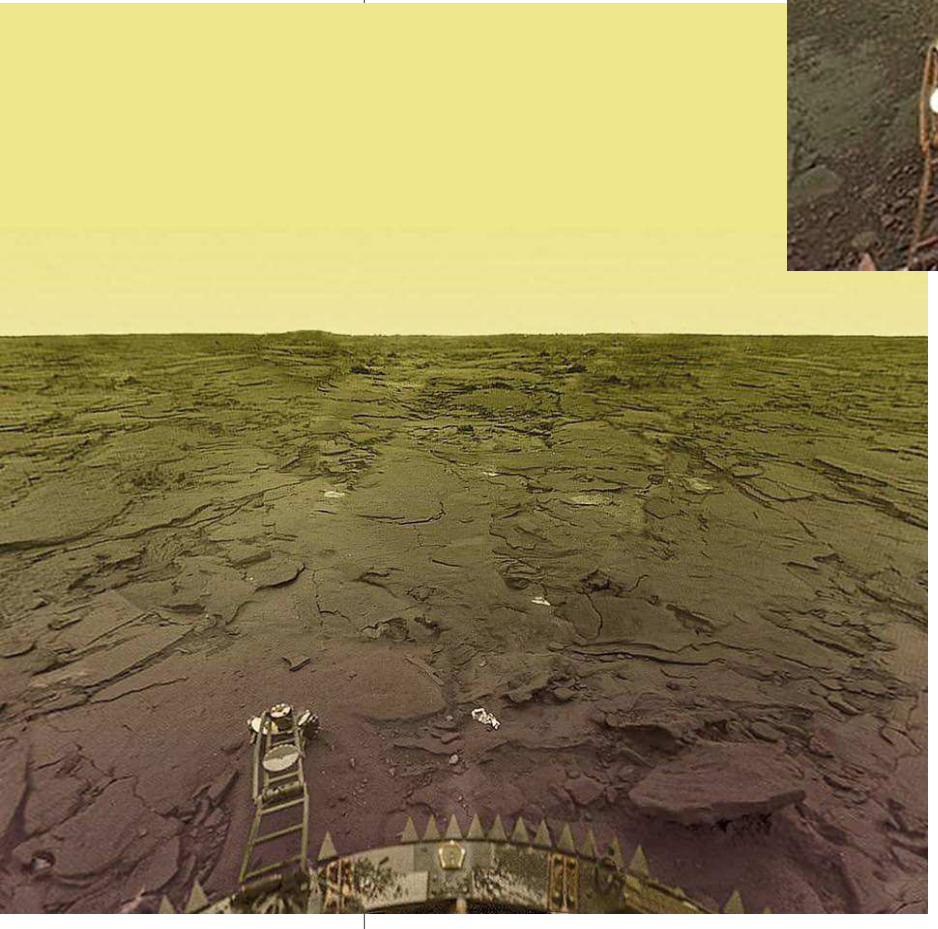


Left, a false-color enhancement of an original photograph of the opaque Venus cloud cover taken by Mariner 10 during its gravity-assist maneuver en route to Mercury in February, 1974. [NASA/JPL] Right, the surface of Venus as captured by the Magellan spacecraft. [Magellan Project/NASA/JPL] On the side, an artistic enlargement of a tiny region of the Venusian atmosphere, showing the geometry of the phosphine molecule. [ESO]



Venusian landscapes photographed by the landers of the Venera 13 and 14 missions in March 1982. [Roscosmos]

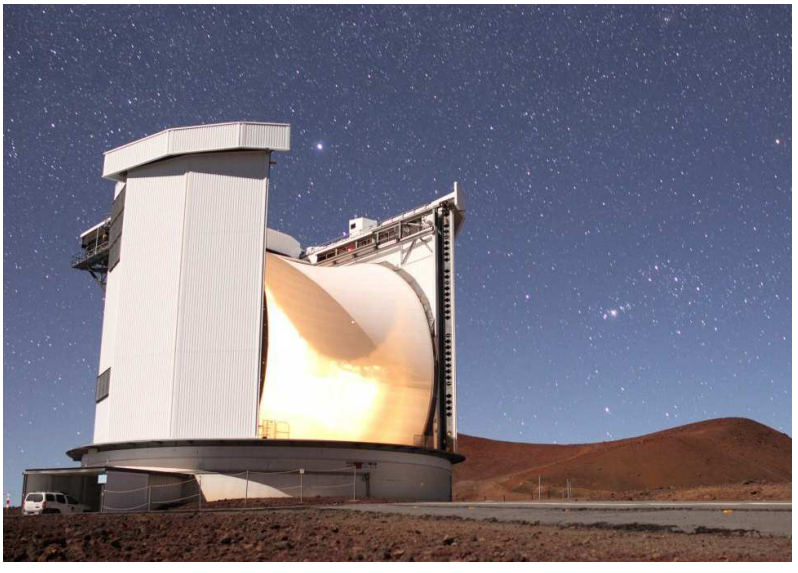
neer missions to land probes during the 1970's and early 1980's, the conditions on Venus can be brutal, with a mean surface temperature of 460 °C. As one moves higher in altitude, the temperature and pressure decrease to where some atmospheric zones might feel quite pleasant. That said, only the heartiest microbe or properly suited human would find the zone safe even for short periods. The Venusian atmosphere is reactive to many small molecules of biological interest – including phosphine. The 96.5% carbon dioxide content drives the "runaway greenhouse effect" that causes the extreme surface temperatures. Sulfuric acid clouds obscure the Venusian surface, making radar the source of our mapping from orbit of the near-entirely of the planet.



Beyond the 3.5% additional nitrogen contribution, all other gases are measured in parts-per-million (ppm) or billion (ppb). The 20 ppb-level phosphine detection was accomplished with the James Clerk Maxwell Telescope, located high above water vapor at the Mauna Kea Observatory in Hawaii, and was confirmed using the Atacama Large Millimeter/submillimeter Array (ALMA), itself located high in the arid Atacama Desert in northern Chile.

During the press briefing, you could sense the scientists trying to reign in the rampant speculation of viewers to focus on how the detection of phosphine is of consequence because we do not have an explanation for how such concentrations could exist in the Venusian atmosphere given what we know

on Earth about its production. Such an interpretation is another example of the principle of mediocrity, a topic of the July-August 2020 issue. If phosphine is produced on Earth by life and we've no other mechanism for its production in significant quantities, we can – at our potential peril and misunderstanding – attribute its presence elsewhere to similar biological processes.



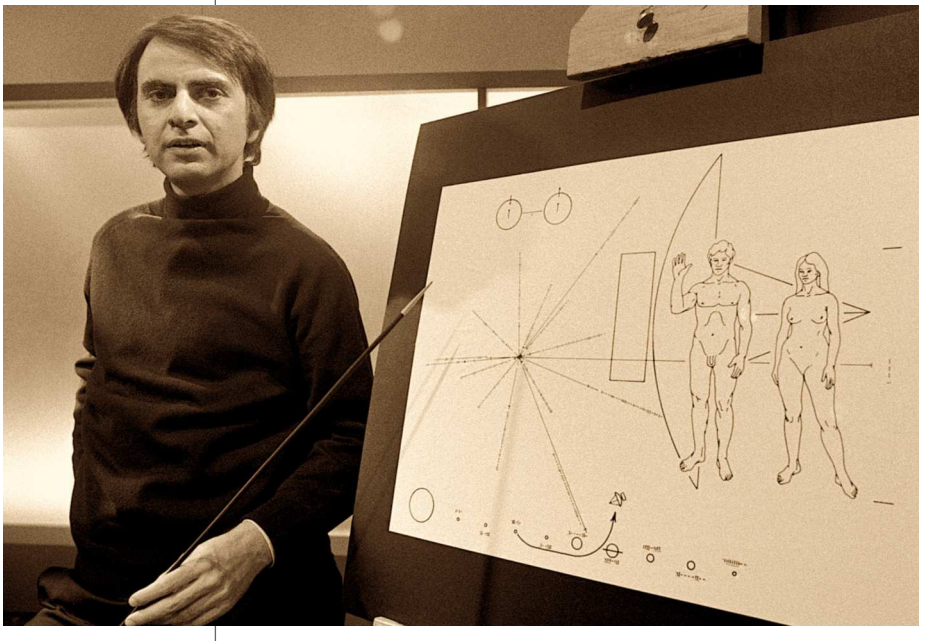
This detection adds a piece of hard data to a debate that, for much of our history, has been driven merely by our knowledge of other planets. The ability to apply hard science to the exobiology question was founded largely on scientific developments at the end of WWII and the political race to prove the superiority of political ideologies during the Cold War – radar technology, detectors across the electromagnetic spectrum, satellites, and interplanetary propulsion. This is why the appearance of more data-driven speculation in the scientific literature, as well as more focus about life far less technologically advanced than our own, only began starting in the 1960's.

A relevant paper was published in *Science* by Carl

Above, the Atacama Large Millimeter/submillimeter Array, high in northern Chile. [W. Garnier, ALMA/ESO/NAOJ/NRAO] Below, the James Clerk Maxwell Telescope, Mauna Kea Observatory, Hawaii. [William Montgomerie]

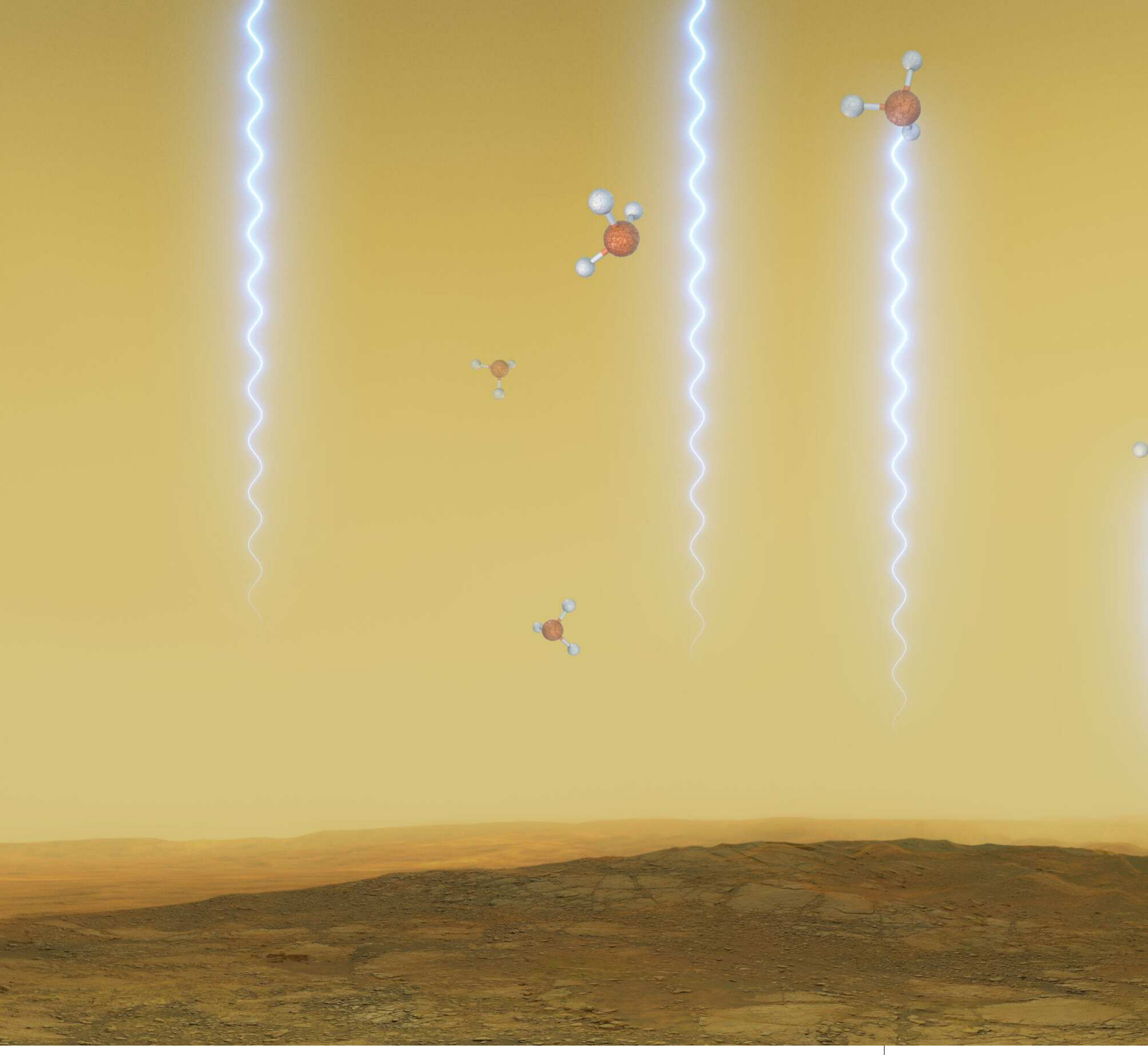
This video summarizes the discovery of phosphine in the atmosphere of Venus. [ESO] Below, the unforgettable Carl Sagan (with the famous message sent on Pioneer probes), who, sixty years ago, had already hypothesized the possible existence of life in the upper atmosphere of Venus. [CBS via Getty images]

Sagan in 1961, titled "The Planet Venus." In it, he comments on the likelihood of detecting life on the surface: *"...it appears quite certain that terrestrial organisms deposited on the surface of the planet would quickly be killed. Consequently, there seems little danger of biological contamination of the surface of Venus."* Enough was then known about the Venusian atmosphere that its possible hosting of simple lifeforms could not so easily be ruled out. Sagan wrote: *"conditions are much more favorable at higher altitudes, especially just beneath the cloud layer, and there is the distinct possibility of biological contamination of the upper Cytherean atmosphere."* The most recent data-driven analysis of Venusian life harkens back to the days of Percival Lowell and his Martian canals, with the Russian scientist Leonid Ksanfomaliti claiming to have found life in images sent back from the Soviet Venera 13 lander mission in 1982. The consensus now is that the disc-like and scorpion-like creatures were, in fact, lens caps and processing artifacts – a clear example of the inverse relationship between data and speculation.



Anyone basing Venusian life on the single-celled organisms inhabiting ponds on Earth would have to take dramatic leaps in biology to make such organisms robust enough to survive the hyper-acidic, poisonous, and water-poor conditions of the upper Venusian atmosphere. That said, similar leaps already abound on Earth. A few examples include *thermococcus gammatolerans*, which can survive high doses of gamma radiation, *pyrococcus furiosus*, which thrives at the boiling point of water (we simple surface-dwellers rely on boiling water to *kill* harmful bacteria), or *clostridium paradoxum*, which is found in acidic mine drainage and volcanic springs. Extreme conditions call for extreme adaptation. We find organisms on Earth existing in places, including the upper atmosphere, where we would not even think to look for them if not for the constant reminder that life, within a very wide range of environments, always finds a way.

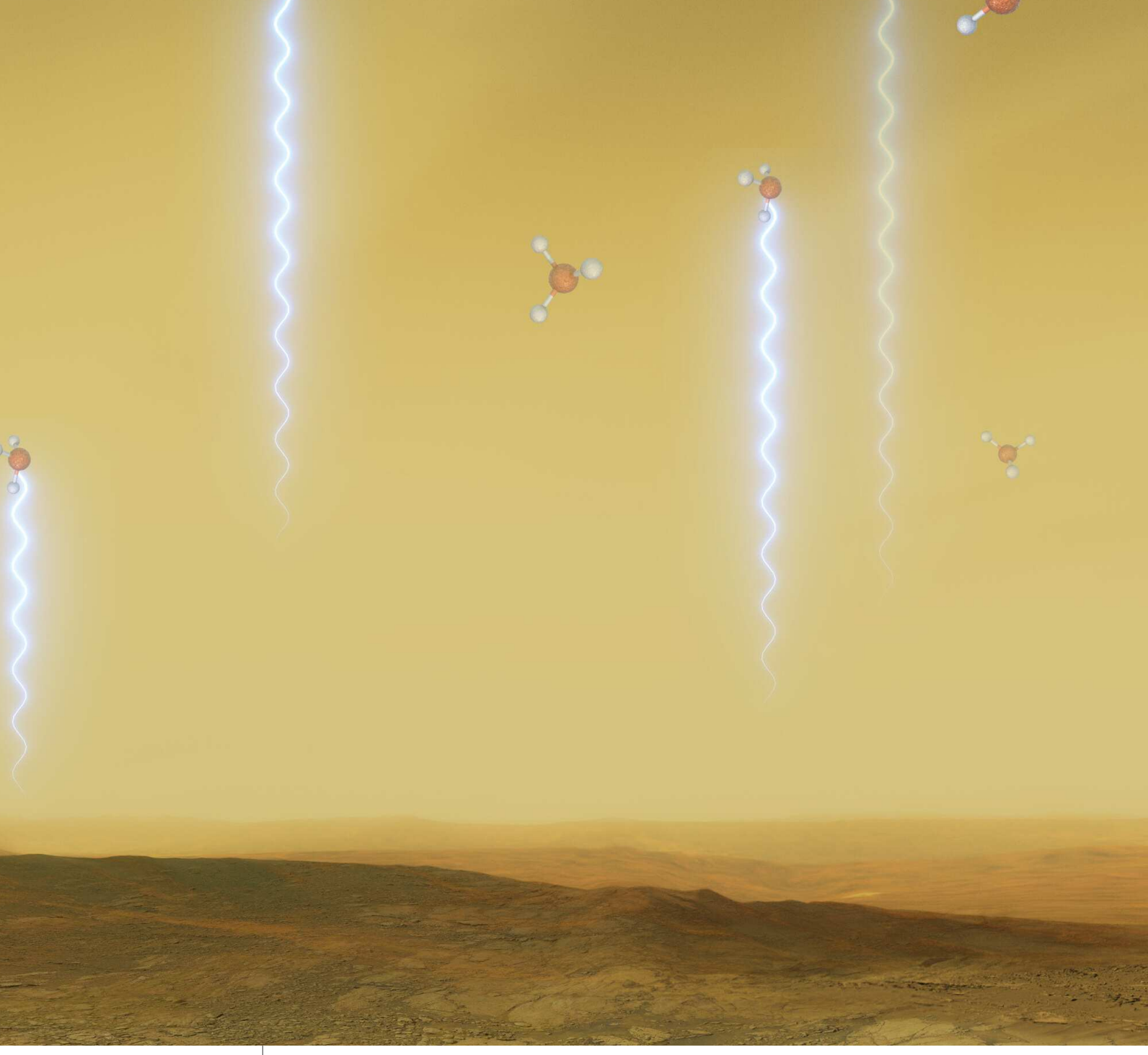
Even without an actual lifeform, the presence of certain small molecules in planetary



atmospheres and their attribution to biological processes is also nothing new, even in our own solar system. Seasonal methane variations in the Martian atmosphere are one example. Methane, CH_4, is broken down by UV radiation. The thin Martian atmosphere provides little protection from solar radiation, resulting in what should mean the eventual depletion of methane. That it is found at all – and changes seasonally – indicates that either some geochemical process is producing methane cyclically or that, possibly, some biological process is occurring that is seasonally restoring atmospheric methane.

While the detection of methane around a rocky exoplanet would be a significant discovery, there is another molecule that would make all of exobiology take notice. Oxygen presently makes up 21% of Earth's atmosphere, but this percentage would itself eventually reduce to zero if not constantly replenished through photosynthesis. In fact, the evolution of life did not begin with aerobic, or oxygen-consuming, respiration. It was the evolution of single-celled organisms capable of photosynthesizing CO_2 and producing O_2 as a waste product that ultimately changed the atmosphere, and evolutionary history, of Earth.

This illustration depicts the Venusian surface and atmosphere, as well as phosphine molecules. These molecules float in the wind-blown clouds at altitudes of 55 to 80 km, absorbing some of the millimeter waves that are produced at lower altitudes. [ESO/M. Kornmesser/L. Calçada]



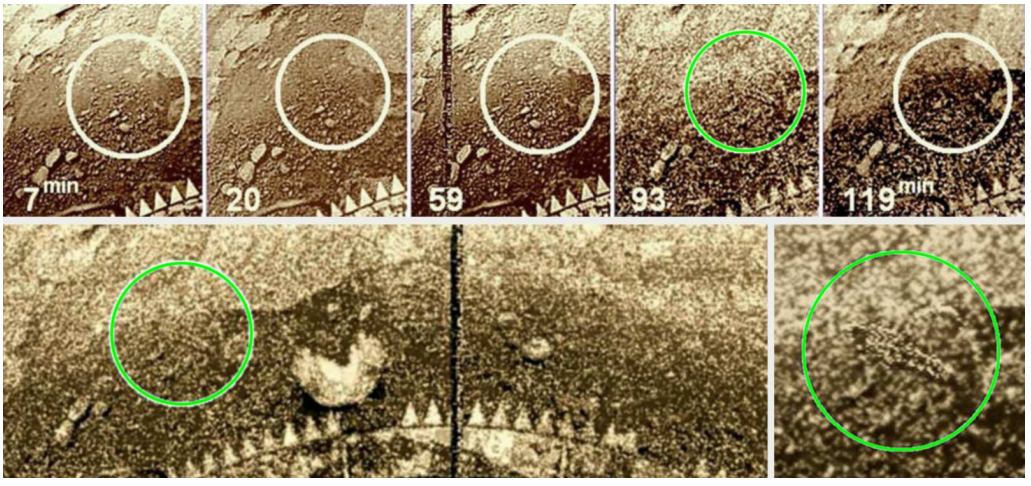
As we search today, the detection of oxygen in an exo-atmosphere does not then mean a wealth of multicellular organisms but may mean that some simple lifeform producing oxygen as a waste product might be responsible for what we detect.

Phosphine, from our current understanding, falls into the same category as meth-ane and oxygen. Without some source to replenish it, it simply should not be detectable in the atmosphere of a rocky planet based on what we currently know of its chemistry. If Venus samples reveal a lifeform producing phosphine (or any molecule!), Earth would go from being alone in the universe to the second planet in its own solar system. Technological sophistication aside, evolution on two close planets with different histories and surface chemistries dramatically expands what exobiologists know to look for. But the ramifications of one or more new lifeforms will not be fully known until scientists are able to determine beyond all doubt that the lifeform is a product of Venus alone. You can, after all, buy Mars rocks – proof that the rocky inner planets have exchanged materials regularly over the history of the solar system.

Consider just one aspect of Earth biology: if the DNA of a Venusian lifeform, if it has

such an information repository, were identical to that of the bases and pairings ("A-T" and "G-C") of life on Earth, it would be easier to accept that either the Venus life or the Earth life came first and one ended up establishing a foothold on the other planet – remembering that early Venus, like early Mars, may have been more hospitable to the chemical processes that began the tree of life we see on Earth today, and that Earth might have become the unanticipated beneficiary of eons of fundamentally different chemical processes elsewhere. If Venusian genetic material were similar, but not quite like DNA, did a small number of resilient extremophiles from Earth/Venus survive the long, cold trip to Venus/Earth and begin to incorporate similar molecular fragments, or have we possibly learned that a stable chemical information repository (like DNA) now is even more established as at the core of biological life? If Venusian genetics was fundamentally different from that on Earth and there was no possible way that stochastic chemical processes could have converted one form into another after some ancient panspermic event, then the case for an entirely separate evolutionary course becomes the accepted theory until future studies can challenge the separate-evolution theory.

In the *Nature Astronomy* paper, the authors take known non-biological processes for phosphine production, including from the known chemistry of the atmosphere and surface of Venus, to further argue for



An artist's vision of the volcanism and hazy atmosphere on the rocky Venusian surface. [ESA/AOES]
On the left, the "scorpion" appeared in the images taken by the Venera 13 lander, about 90 minutes after landing, and noticed by Leonid Ksanfomaliti. It was actually an image processing artifact. [Roscosmos]

a potential biological origin. The study of non-biological phosphine sources will undoubtedly come to be a new research focus. Despite our great hope of finding extraterrestrial life, the scientific community is always ready to apply Occam's Razor to any such claim. Scientific skepticism at extraterrestrial claims might always be treated as if an alternative explanation is the more likely one. As Sagan said, *"extraordinary claims require extraordinary evidence."*

Of all of the statements made about the phosphine discovery and analysis, perhaps the most complicated one was published by the Organising Committee of Commission F3 of the International Astronomical Union itself, which seems to admonish the authors for even pushing the biological origin hypothesis. From the statement: *"the Commission is concerned with the way the potential detection of phosphine has been covered for the broad audience. It is an ethical duty for any scientist to communicate with the media and the public with great scientific rigor and to be careful not to overstate any interpretation which will be irretrievably picked up by the press and generate great public attention in the case of life beyond Earth."* The interpretation of the statement among several members of the astronomy community has been varied, but Oxford Professor and BBC *The Sky at Night* host Dr. Chris Lintott has summed up the thoughts of many, describing the statement as a *"grumpy response of a bunch of senior people not involved in work that got public attention."* With the IAU executive presently calling for the F3 statement retraction, there has officially been a controversy over the possible detection of biological processes on Venus, a controversy over the F3 response to the controversy, and now any future IAU controversies over the F3 controversy over the response to the controversy. Social media astrophiles are free to sit back and watch how the professionals do it.

A speculative vision of possible Venusian life as described in the classic introductory book National Geographic Picture Atlas of Our Universe. *[Nat.Geo.]*

As will be true for exoplanets, it is possible that a strong marker of Venusian biology is already visible to us, but we do not yet recognize it as a marker - either food, waste, oxidant, or whatever life does as part of its existence. The phosphine discovery bridges one possible gap and, if life always happens to find a similar way in the universe, its detection could be the beginning of our new chapter in the biology of the universe. Until then, there remain a great many studies. ■

NORT

RAPIDO 450

ALTAZIMUTH NEWTONIAN TELESCOPE

- SCHOTT Supremax 33 optics
- optical diameter: 460 mm
- useful diameter: 450 mm
- focal ratio: f/4
- primary mirror thickness: 35 mm
- minor axis secondary mirror: 100 mm
- axial cell cooling system
- multi-fan removal of the mirror surface boundary layer
- carbon truss with self-centering conical couplings
- lateral supports (six) designed for altazimuth instruments
- zero deformations

The NortheK Rapido 450 is designed to be disassembled into essential parts for transport in a small car. Each component is equipped with its own case, facilitating transport and assembly. The main element weighs 27 kg. Incorporated mechanical devices and the precise execution of each component allows for the collimation of the optics with extreme ease, maintaining collimation throughout an observation session while eliminating twisting and bending, regardless of the weight of the accessories used. The very thin primary optic allows for rapid acclimatization and ensures thermal stability throughout the night. Two bars equipped with sliding weights allow for the perfect balance of the telescope and accessories. On demand, it is also possible to modify the support to mount the telescope on an equatorial platform. This instrument is composed of aluminum, carbon and steel, each perfectly selected according to strict mechanical standards. It is undoubtedly the best altazimuth Newtonian on the market.

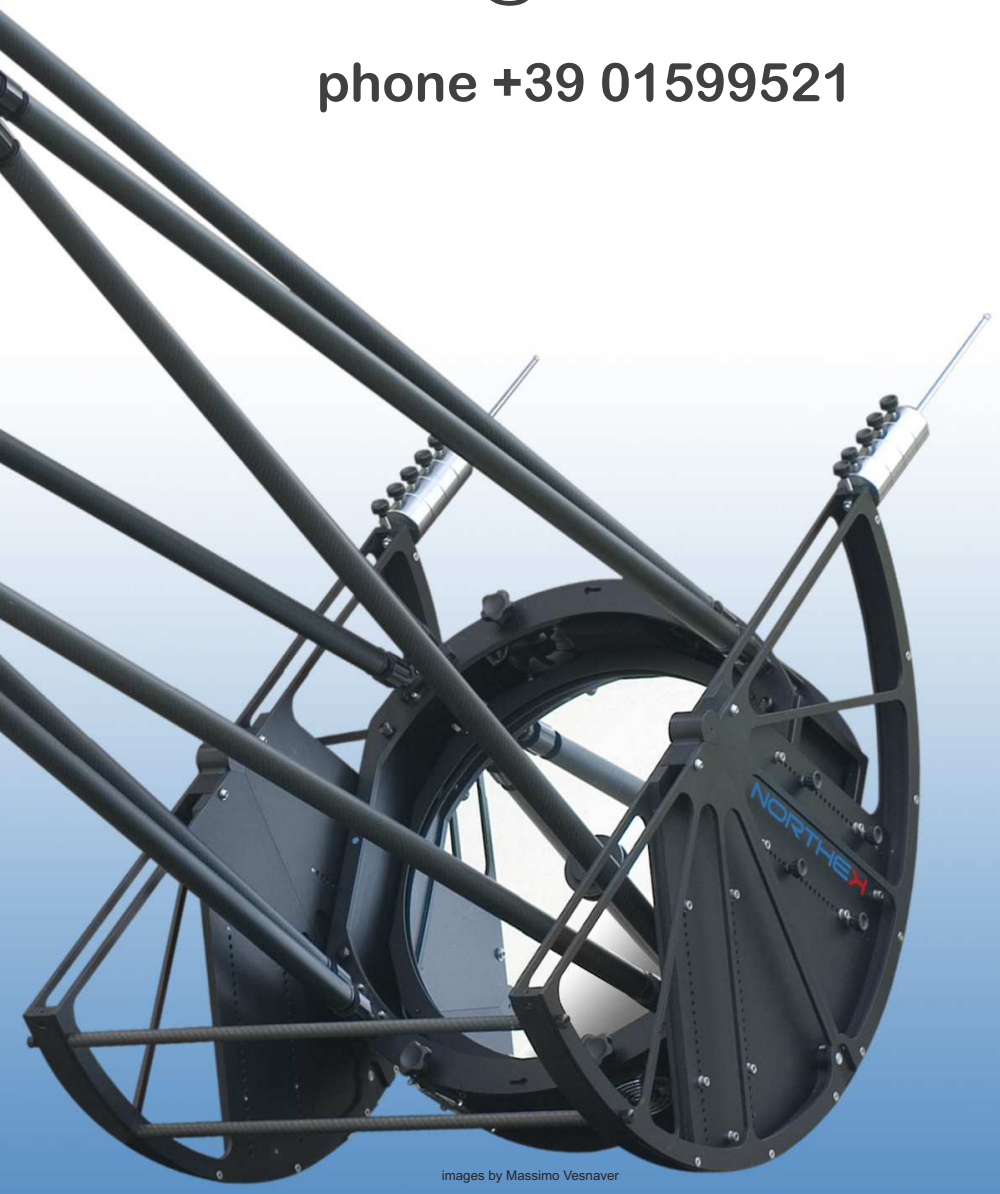
ΓΗΕΚ

www.northek.it

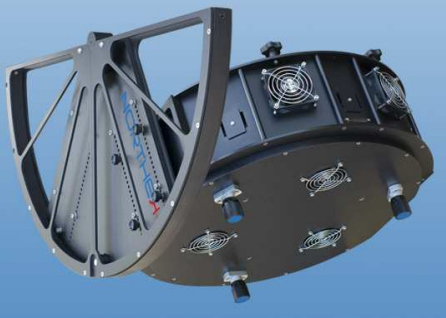
www.facebook.com/northek.it

info@northek.it

phone +39 01599521



images by Massimo Vesnaver



M P O S I T E S - O P T I C S

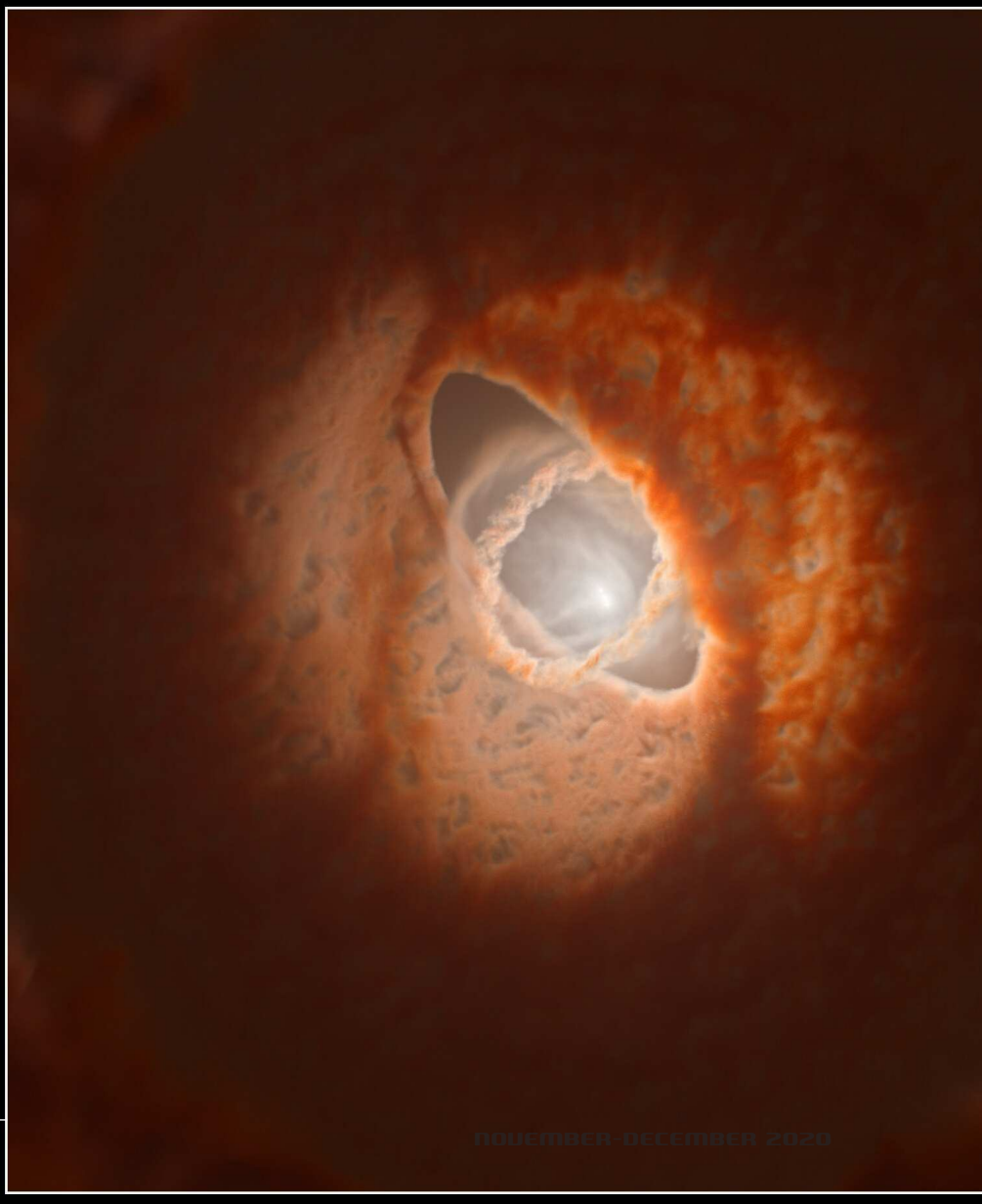
A planet-forming disc torn apart by its three central stars

by ESO

A team of astronomers have identified the first direct evidence that groups of stars can tear apart their planet-forming disc, leaving it warped and with tilted rings. This new research suggests exotic planets, not unlike Tatooine in Star Wars, may form in inclined rings in bent discs around multiple stars. The results were made possible thanks to observations with the European Southern Observatory's Very Large Telescope (ESO's VLT) and the Atacama Large Millimeter/submillimeter Array (ALMA).

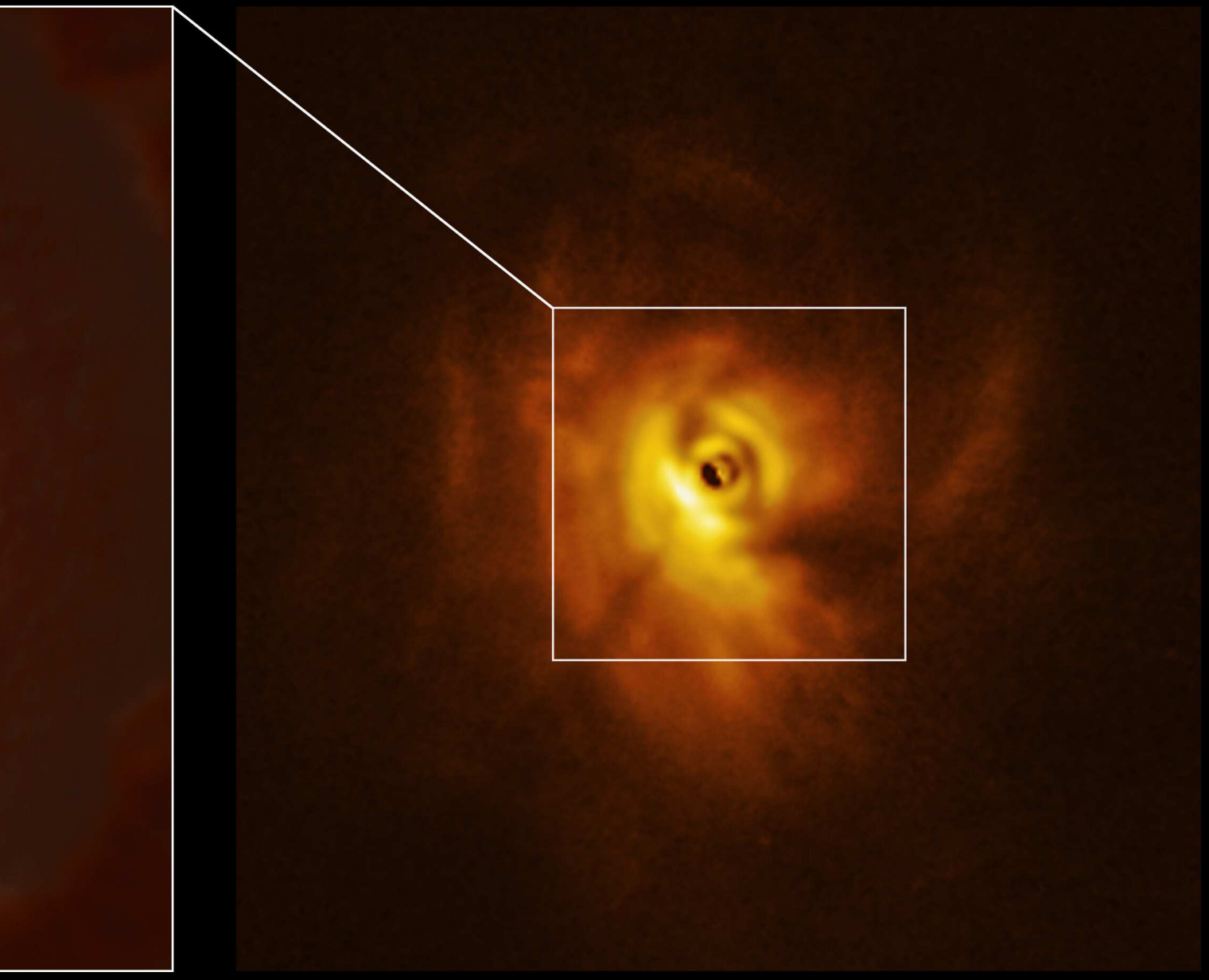
Our Solar System is remarkably flat, with the planets all orbiting in the same plane. But this is not always the case, especially for planet-forming discs around multiple stars, like the object of the new study: GW Orionis. This system, located just over 1300 light-years away in the constellation of Orion, has three stars and a deformed, broken-apart disc surrounding them.

"Our images reveal an extreme case where the disc is not flat at all, but is warped and has a misaligned ring that has broken away from the disc," says Stefan Kraus, a professor of astrophysics at the University of Exeter in the UK who led the research published in the journal *Science*. The misaligned ring is located in the inner part of the disc, close to the three stars.



The new research also reveals that this inner ring contains 30 Earth-masses of dust, which could be enough to form planets. *"Any planets formed within the misaligned ring will orbit the star on highly oblique orbits and we predict that many planets on oblique, wide-separation orbits will be discovered in future planet imaging campaigns, for instance with the ELT,"* says team member Alexander Kreplin of the University of Exeter, referring to ESO's Extremely Large Telescope, which is planned to start operating later this decade. Since more than half the stars in the sky are born with one or more companions, this raises an exciting prospect: there could be an unknown population of exoplanets that orbit their stars on very inclined and distant orbits.

ALMA, in which ESO is a partner, and the SPHERE instrument on ESO's Very Large Telescope have imaged GW Orionis, a triple star system with a peculiar inner region. The new observations revealed that this object has a warped planet-forming disc with a misaligned ring. In particular, the SPHERE image (right panel) allowed astronomers to see, for the first time, the shadow that this ring casts on the rest of the disc. This helped them figure out the 3D shape of the ring and the overall disc. The left panel shows an artistic impression of the inner region of the disc, including the ring, which is based on the 3D shape reconstructed by the team. [ESO/L. Calçada, Exeter/Kraus et al.]



To reach these conclusions, the team observed GW Orionis for over 11 years. Starting in 2008, they used the AMBER and later the GRAVITY instruments on ESO's VLT Interferometer in Chile, which combines the light from different VLT telescopes, to study the gravitational dance of the three stars in the system and map their orbits. *"We found that the three stars do not orbit in the same plane, but their orbits are misaligned with respect to each other and with respect to the disc,"* says Alison Young of the Universities of Exeter and Leicester and a member of the team.

They also observed the system with the SPHERE instrument on ESO's VLT and with ALMA, in which ESO is a partner, and were able to image the inner ring and confirm its misalignment. ESO's SPHERE also allowed them to see, for the first time, the shadow that this ring casts on the rest of the disc. This helped them figure out the 3D shape of the ring and the overall disc.

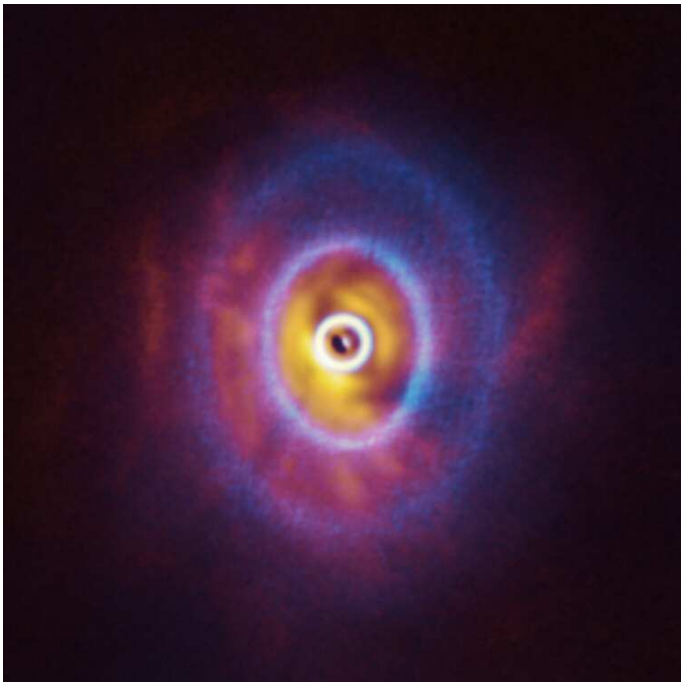
The international team, which includes researchers from the UK, Belgium, Chile, France and the US, then combined their exhaustive observations with computer simulations to understand what had happened to the system. For the first time, they were able to clearly link the observed misalignments to the theoretical "disc-tearing effect", which suggests that the conflicting gravitational pull of stars in different planes can warp and break their discs.

Their simulations showed that the misalignment in the orbits of the three stars could cause the disc around them to break into distinct rings, which is exactly what they see in their observations. The observed shape of the inner ring also matches predictions from numerical simulations on how the disc would tear.

Interestingly, another team who studied the same system using ALMA believe another ingredient is needed to understand the system. *"We think that the presence of a planet between these rings is needed to explain why the disc tore apart,"* says Jiaqing Bi of the University of Victoria in Canada who led a study of GW Orionis published in *The Astrophysical Journal Letters* in May this year. His team identified three dust rings in the ALMA observations, with the outermost ring being the largest ever observed in planet-forming discs.

Future observations with ESO's ELT and other telescopes may help astronomers fully unravel the nature of GW Orionis and reveal young planets forming around its three stars. ■

This 'fly-through' animation allows the viewer to see the three stars at the very centre of GW Orionis, as well as its warped disc and the tilted ring that was torned apart from it. The animation is based on a computer model of the inner region of GW Orionis, provided by the team; they were able to reconstruct the 3D orbits of the stars and the 3D shape of the disc from the observational data. [ESO/Exeter/ Kraus et al., ALMA (ESO/NAOJ/NRAO)]

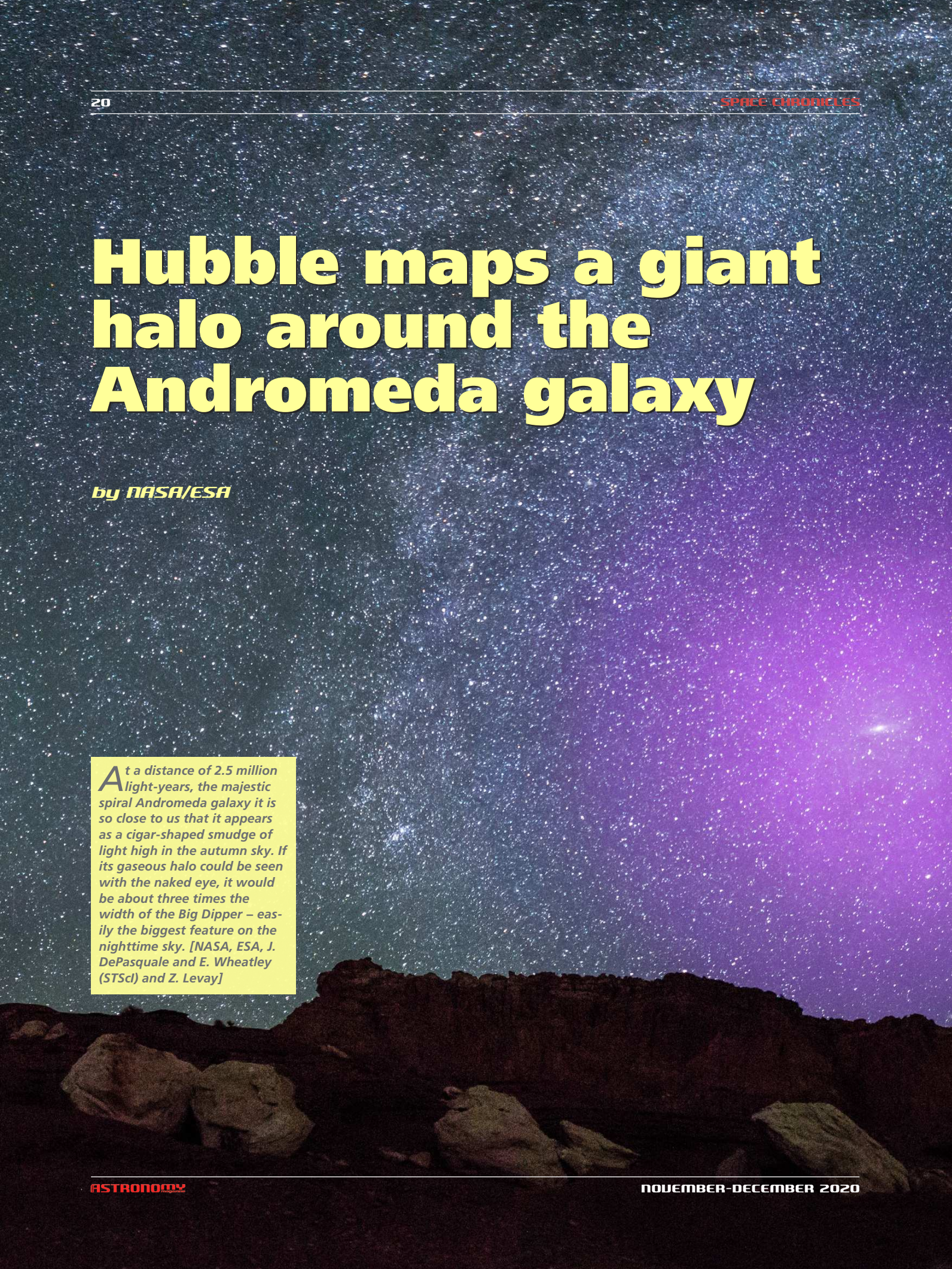


This ALMA image shows the disc's ringed structure, with the innermost ring (part of which is visible as an oblong dot at the very centre of the image) separated from the rest of the disc. The SPHERE observations allowed astronomers to see for the first time the shadow of this innermost ring on the rest of the disc, which made it possible for them to reconstruct its warped shape. [ESO/Exeter/ Kraus et al., ALMA (ESO/NAOJ/NRAO)]

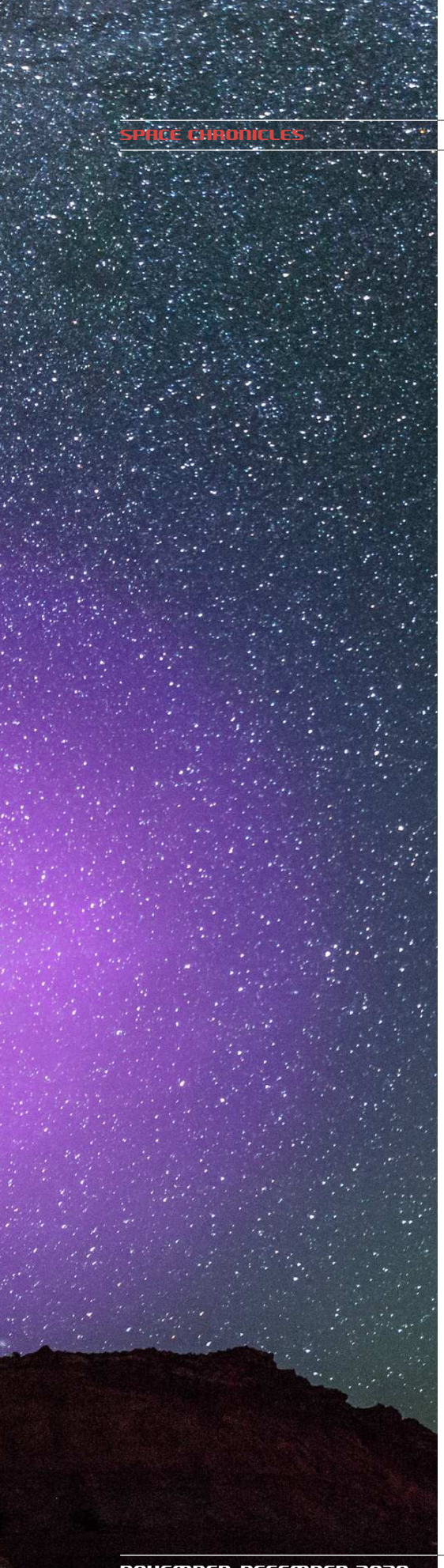

Tabby's star, un mystère non résolu
Deux sondes exploreront le système solaire primitif
Twin spends 340 days in orbit
Bloostar: space at your fingertips
Missione PLATO, il passo decisivo
Le pulsar nel mirino di NICER
Cinque anni di Curiosity
Une autre origine pour la ceinture d'astéro
Deep Space Gateway, repartir de la Lune
The first interstellar asteroid
L'industrie minière va au-delà de la Terre
Une nouvelle Supernova au-dessus de Munich
Noticias desde el sistema TRAPPIST
Hayabusa2 trabajando en Ryugu
Le projet Genesis et la protection planétaire
Le rover Opportunity est à la retraite
Barnard's Star b, la super-Terra più vicina
Bennu, Didymoon e la difesa planetaria
50 years ago, we walked on the Moon
PART ONE OF TWO

Hubble maps a giant halo around the Andromeda galaxy

by NASA/ESA



At a distance of 2.5 million light-years, the majestic spiral Andromeda galaxy it is so close to us that it appears as a cigar-shaped smudge of light high in the autumn sky. If its gaseous halo could be seen with the naked eye, it would be about three times the width of the Big Dipper – easily the biggest feature on the nighttime sky. [NASA, ESA, J. DePasquale and E. Wheatley (STScI) and Z. Levay]



In a landmark study, scientists using NASA's Hubble Space Telescope have mapped the immense envelope of gas, called a halo, surrounding the Andromeda galaxy, our nearest large galactic neighbor. Scientists were surprised to find that this tenuous, nearly invisible halo of diffuse plasma extends 1.3 million light-years from the galaxy—about halfway to our Milky Way—and as far as 2 million light-years in some directions. This means that Andromeda's halo is already bumping into the halo of our own galaxy.

They also found that the halo has a layered structure, with two main nested and distinct shells of gas. This is the most comprehensive study of a halo surrounding a galaxy.

"Understanding the huge halos of gas surrounding galaxies is immensely important," explained co-investigator Samantha Berek of Yale University in New Haven, Connecticut. *"This reservoir of gas contains fuel for future star formation within the galaxy, as well as outflows from events such as supernovae. It's full of clues regarding the past and future evolution of the galaxy, and we're finally able to study it in great detail in our closest galactic neighbor."*

"We find the inner shell that extends to about a half million light-years is far more complex and dynamic," explained study leader Nicolas Lehner of the University of Notre Dame in Indiana. *"The outer shell is smoother and hotter. This difference is a likely result from the impact of supernova activity in the galaxy's disk more directly affecting the inner halo."*

A signature of this activity is the team's discovery of a large amount of heavy elements in the gaseous halo of Andromeda. Heavier elements are cooked up in the interiors of stars and then ejected into space — sometimes violently as a star dies. The halo is then contaminated with this material from stellar explosions. The Andromeda galaxy, also known as M31, is a majestic spiral of perhaps as many as 1 trillion stars and comparable in size to our Milky Way. At a distance of 2.5 million light-years, it is so close to us that the galaxy appears as a cigar-shaped smudge of light high in the autumn sky. If its gaseous halo could be viewed with the naked eye, it would be about three times the width of the Big Dipper. This would easily be the biggest feature on the nighttime sky.

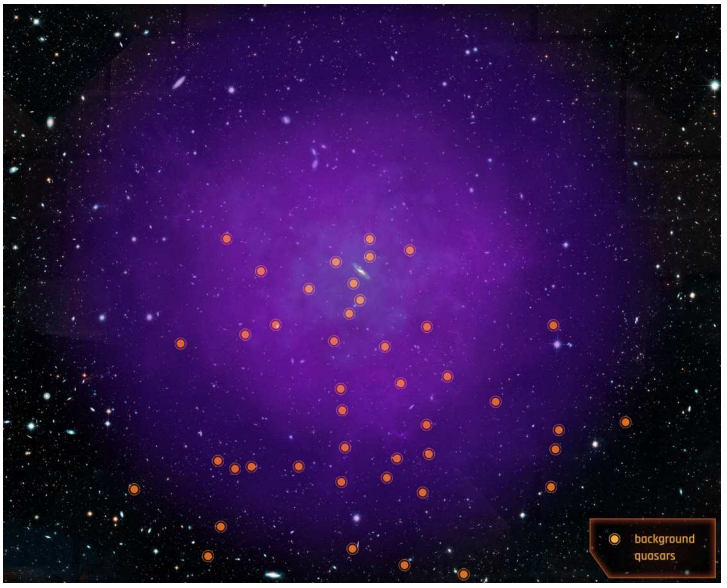
Through a program called Project AMIGA (Absorption Map of Ionized Gas in Andromeda), the study examined the light from 43 quasars—the very distant, brilliant cores of active galaxies powered by black holes—located far beyond Andromeda. The quasars are scattered behind the halo, allowing scientists to probe multiple regions. Looking through the halo at the quasars' light, the team observed how this light is absorbed by the Andromeda halo and how that absorption changes in different regions. The immense Andromeda halo is made of very rarified and ionized gas that doesn't emit radiation that is easily detectable. Therefore, tracing the absorption of light coming from a background source is a better way to probe this material.

The researchers used the unique capability of Hubble's Cosmic Origins Spectrograph (COS) to study the ultraviolet light from the quasars. Ultraviolet light is absorbed by Earth's atmosphere, which makes it impossible to observe with ground-based telescopes. The team used COS to detect ionized gas from carbon, silicon and oxygen. An atom becomes ionized when radiation strips one or more electrons from it.

Andromeda's halo has been probed before by Lehner's team. In 2015, they discovered that the halo is large

and massive. But there was little hint of its complexity; now, it's mapped out in more detail, leading to its size and mass being far more accurately determined.

"Previously, there was very little information—only six quasars—within 1 million light-years of the galaxy. This new program provides much more information on this inner region of Andromeda's halo," explained co-investigator J. Christopher Howk, also of Notre Dame. *"Probing gas within this radius is important, as it represents something of a gravitational sphere of influence for Andromeda."*



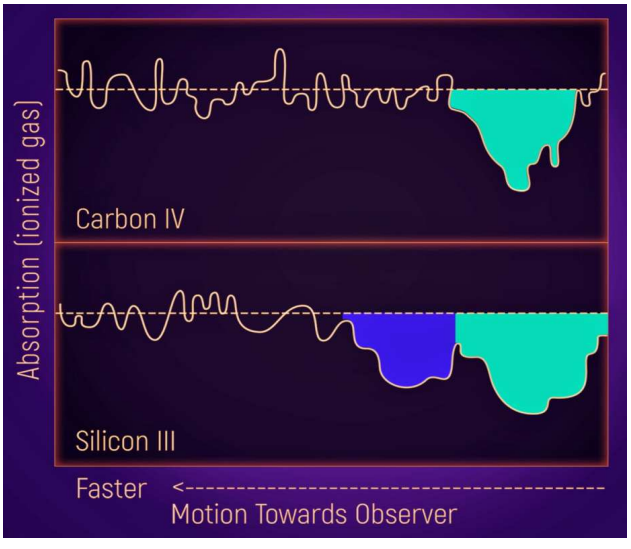
This illustration shows the location of the 43 quasars scientists used to probe Andromeda's gaseous halo. These quasars are scattered far behind the halo, allowing scientists to probe multiple regions. Looking through the immense halo at the quasars' light, the team observed how this light is absorbed by the halo and how that absorption changes in different regions. By tracing the absorption of light coming from the background quasars, scientists are able to probe the halo's material. [NASA, ESA, and E. Wheatley (STScI)]

Because we live inside the Milky Way, scientists cannot easily interpret the signature of our own galaxy's halo. However, they believe the halos of Andromeda and the Milky Way must be very similar since these two galaxies are quite similar. The two galaxies are on a collision course, and will merge to form a giant elliptical galaxy beginning about 4 billion years from now.

Scientists have studied gaseous halos of more distant galaxies, but those galaxies are much smaller on the sky, meaning the number of bright enough background quasars to probe their halo is usually only one per galaxy. Spatial information is therefore essentially lost. With its close proximity to Earth, the gaseous halo of Andromeda looms large on the sky, allowing for a far more extensive sampling.

"This is truly a unique experiment because only with Andromeda do we have information on its halo along not only one or two sightlines, but over 40," explained Lehner. *"This is groundbreaking for capturing the complexity of a galaxy halo beyond our own Milky Way."*

In fact, Andromeda is the only galaxy in the universe for which this experiment can be done now, and only with Hubble. Only with an ultraviolet-sensitive future space telescope will scientists be able to routinely undertake this type of experiment beyond the approximately 30 galaxies comprising the Local Group. *"So Project AMIGA has also given us a glimpse of the future,"* concluded Lehner. ■



This diagram shows the light from a background quasar passing through the vast, gaseous halo around the neighboring Andromeda galaxy (M31), as spectroscopically measured by the Hubble Space Telescope. The colored regions show absorption from two components that make up the halo. For ionized silicon, a significant absorption is shown in both plots. The more highly ionized carbon is absorbed by only one component. Astronomers can tell the two components apart because their line-of-sight motions, known as radial velocity, cause a Doppler shift that changes the wavelength of light being absorbed. [NASA, ESA, and E. Wheatley (STScI)]

NEW MOON TELESCOPES

nmt

The Hybrid

The Classic

Hand Crafted Dobsonians- Made to Order

From 8" to 36"

Featuring The All New SOLID Wood / Aluminum HYBRID!

YouTube

www.newmoontelescopes.com ryan@newmoontelescopes.com

The Anthropoc an interstellar

by Michele Ferrara

revised by Damian G. Allis
NASA Solar System Ambassador

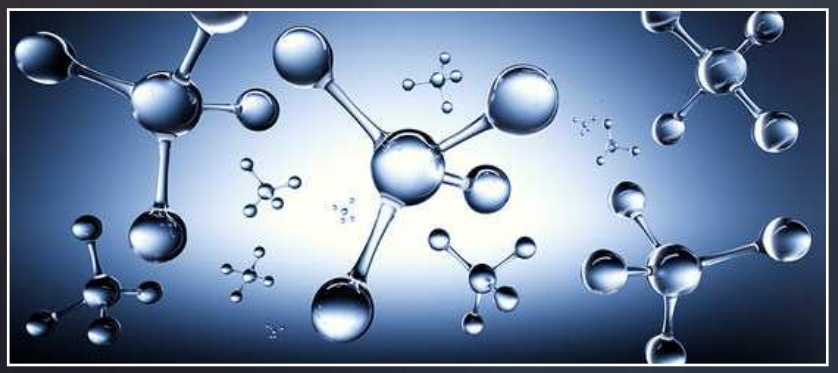
It seems incredible, but in an age when humans communicated remotely using horseback couriers, carrier pigeons, fires and mirrors, the first signals were already being transmitted into space. The Roman, Chinese and Spanish empires unwittingly added traces of their existence to the light reflected from the Earth, and we cannot entirely exclude that those traces have already been noticed by an extraterrestrial civilization.

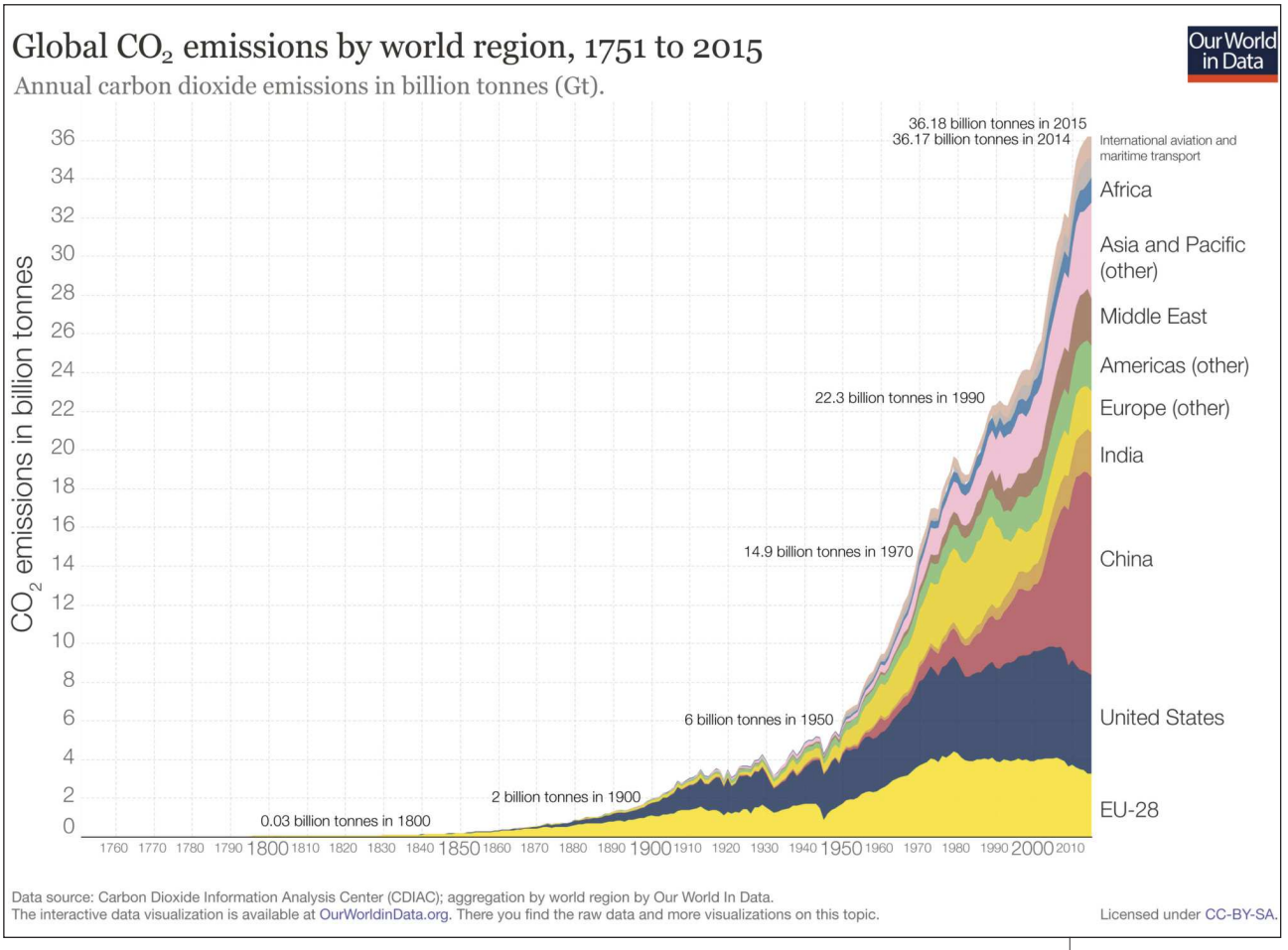
In the next few years, we will be able to analyze the atmospheres of the nearest exoplanets and understand if they contain molecules consistent with the presence of life. Perhaps in those atmospheres, it will also be possible to recognize "pollutants," gases not produced by natural processes that could be the result of activities associated with particularly advanced and intelligent life forms. Regardless of the composition of each atmosphere, any observation will provide a snapshot dating back to the moment when the light collected by our instruments left the source. Theoretically, that light, properly analyzed, can tell us if there is an

ene as messenger

The atmosphere is the calling card of the Earth. To the eyes of a distant observer, the periods in which it appears most polluted may be evident. Today it is very much polluted, and one of the most worrying pollutants is methane (CH_4), the molecular geometry of which is represented alongside. [Hamish Weir]

advanced civilization on a particular planet and if they are at some level of development similar to some level of ours over the course of our history. It is understandable that atmospheres polluted over a longer period of time will be recognizable at greater distances from the Earth compared to those in which pollution has only recently begun, as the light that carries traces of gases of non-natural origin will have traveled for longer. Observations of this type will be clearly limited by the resolving power of the instruments

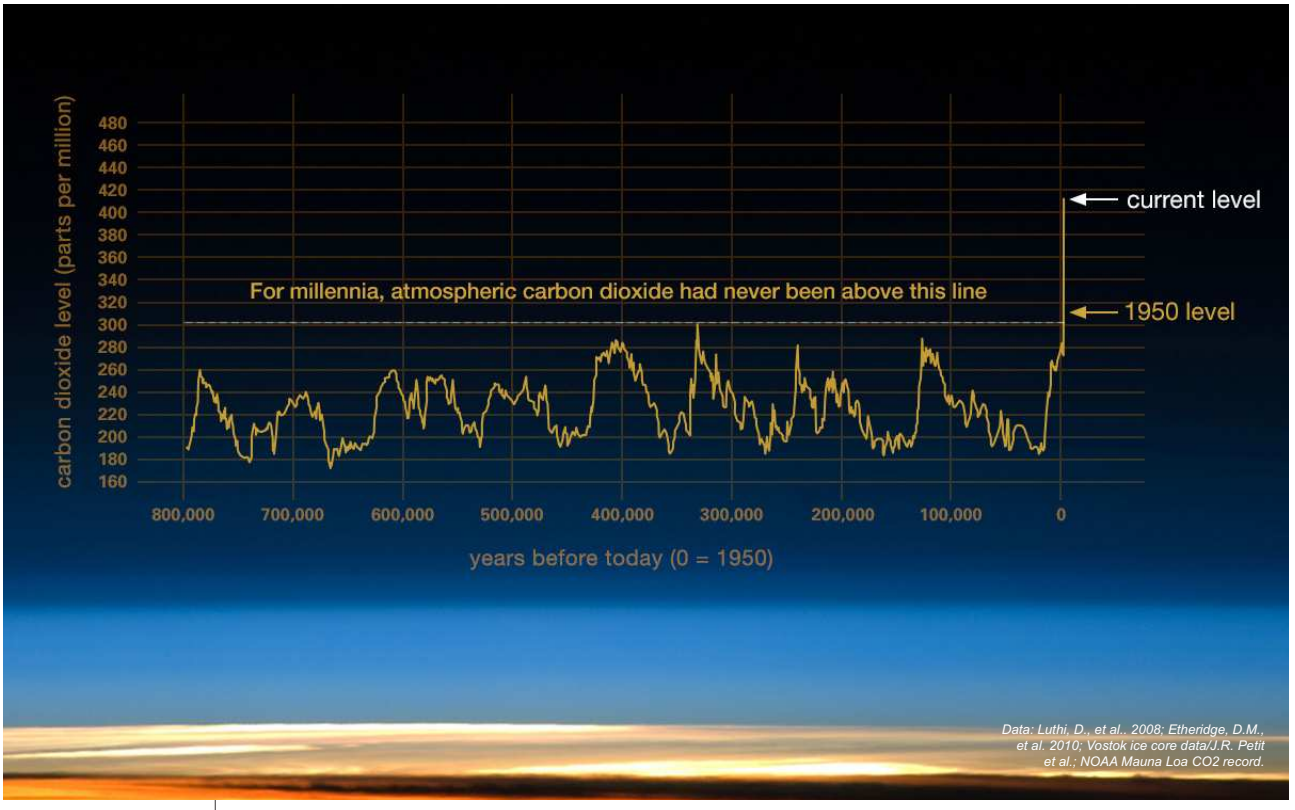




used (which, especially in the presence of low abundances, may not allow for the correct distinction of gases), but also conditioned by our current models on the formation and evolution of planets and their atmospheres. Despite this, there is no doubt that, in certain scenarios, specific molecules either cannot be produced by natural processes or cannot persist in planetary atmospheres without the support of biological activities. There are no solid arguments to assert that the life present on other planets might have a totally different impact on their atmospheres compared to the only case we know. Therefore, if another civilization has evolved by polluting its own atmosphere, our methods of investigation should be able to discover it (within certain limits, of course). Obviously, this opportunity is not one-way. Pollution of the Earth's atmosphere is also detectable from other planetary systems and it would be interesting to know how far away that detection can occur, as that is the limit beyond which an alien observer can only detect the generic presence of life on our planet but not the presence of an evolved civilization. This is equivalent to saying that, beyond such limit, it does not make much sense looking for possible messages intentionally sent to us. Understanding how far the light reflected from our polluted atmosphere has gone can ultimately improve the targeting of some SETI programs.

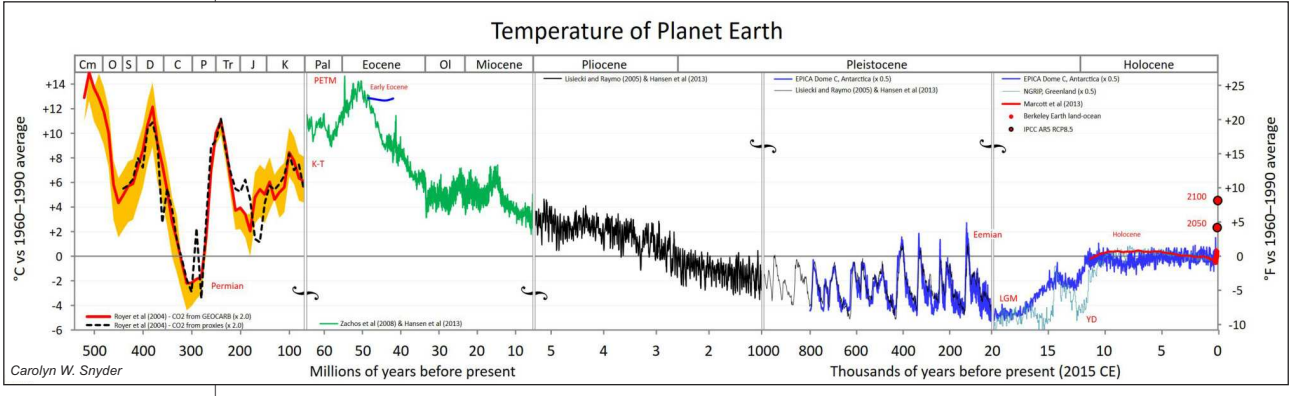
To determine that distance, we must take a trip through the Anthropocene. This term (introduced in the 1980s by the US bi-

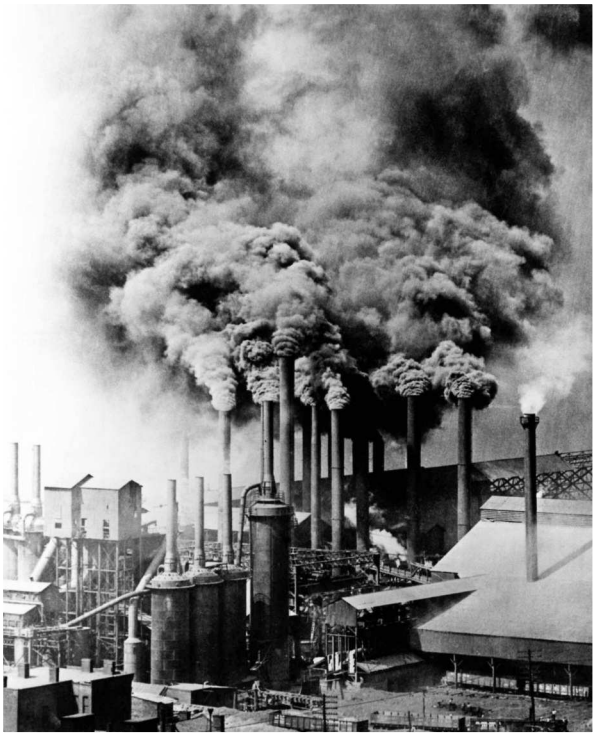
In this graph of global carbon dioxide emissions from the time of the first Industrial Revolution, it can be seen that that initial, intense period of atmospheric pollution is negligible compared to the emissions of the last century. [CDIAC]



Above, the changes in CO_2 in the atmosphere over the last 800,000 years. Below, the changes in temperature since the beginning of the Cambrian, when life was essentially aquatic.

ologist Eugene Filmore Stoermer) indicates the period within which the impact of human activity on the environment produced effects that are unequivocally distinguishable from those produced by natural phenomena and processes. The Anthropocene *de facto* overlaps a more or less extensive part of the Holocene, the most recent geological epoch (the last of the Quaternary) and the one we now live in, which conventionally began about 11,700 years ago at the end of the Würm Glaciation. The anthropogenic (man-made) environmental changes recognizable in the Holocene have different weights depending on the aspects considered. Here we are essentially interested in identifying the historical context in which human activity has indisputably produced widespread and persistent atmospheric pollution. There is

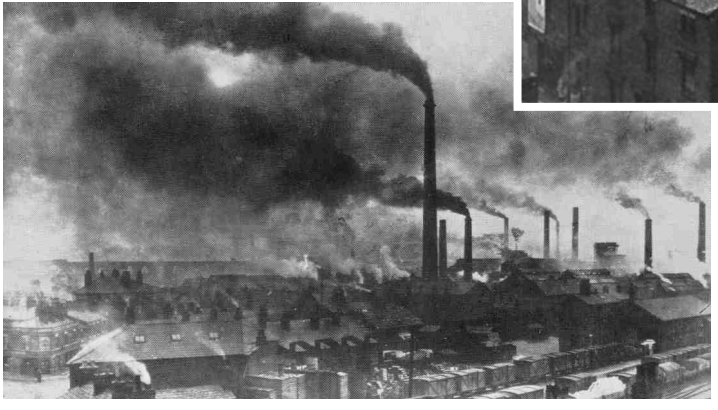


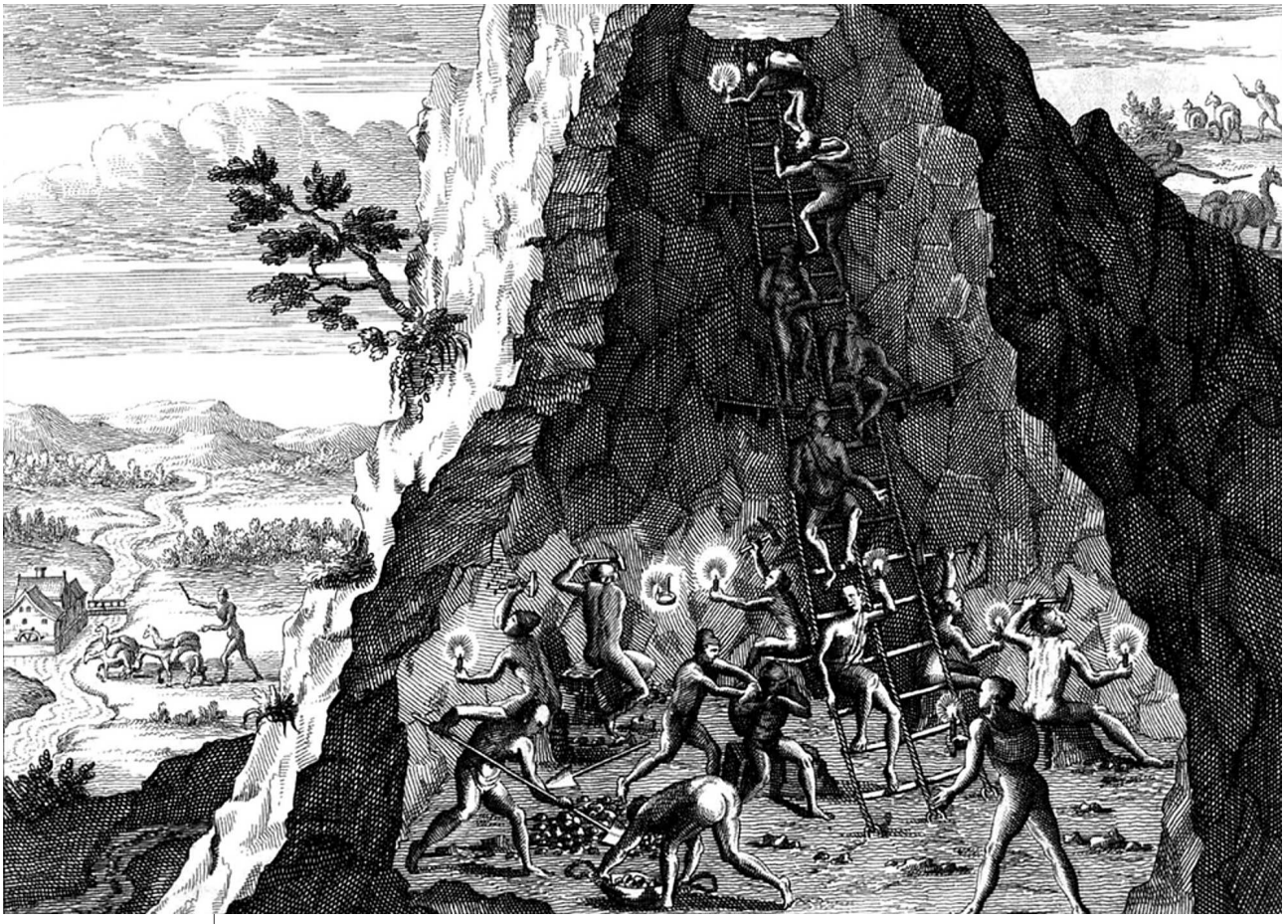


Impressive images that testify to the appalling air pollution that oppressed large urban centers in the first decades of the Industrial Revolution. About 200 light years from Earth, the traces of this scenario are certainly recognizable.

and fossil fuels considerably increased the presence of carbon dioxide and sulfur dioxide in the atmosphere.
All the molecules produced in large quantities by human activities in the last two and a half centuries would be clearly visible in the light of our planet collected and analyzed by an observer placed at a maximum distance of about 250 light years. Within this radius there are at least 200,000 stars, some of which could host planets suitable for the development of life.
Even with a strict selection, for example considering only solar-type stars with an age of not less than four billion years, there would still be thousands of targets to be explored with specific SETI programs. Undoubtedly, the last two and a half centuries of industrialization have strongly characterized the Anthropocene, but minor and more local-

no doubt that, from planets a few tens of light years away, anomalous abundances of (for example) benzene, toluene, nitrogen oxides, carbon monoxide, carbon dioxide, methane and various metals would be easily distinguishable. Some of these elements and chemical compounds began to be massively released into the atmosphere starting with the first Industrial Revolution, begun in England in 1760 and driven by the improvement of the steam engine. Inevitably, the growing demand for wood





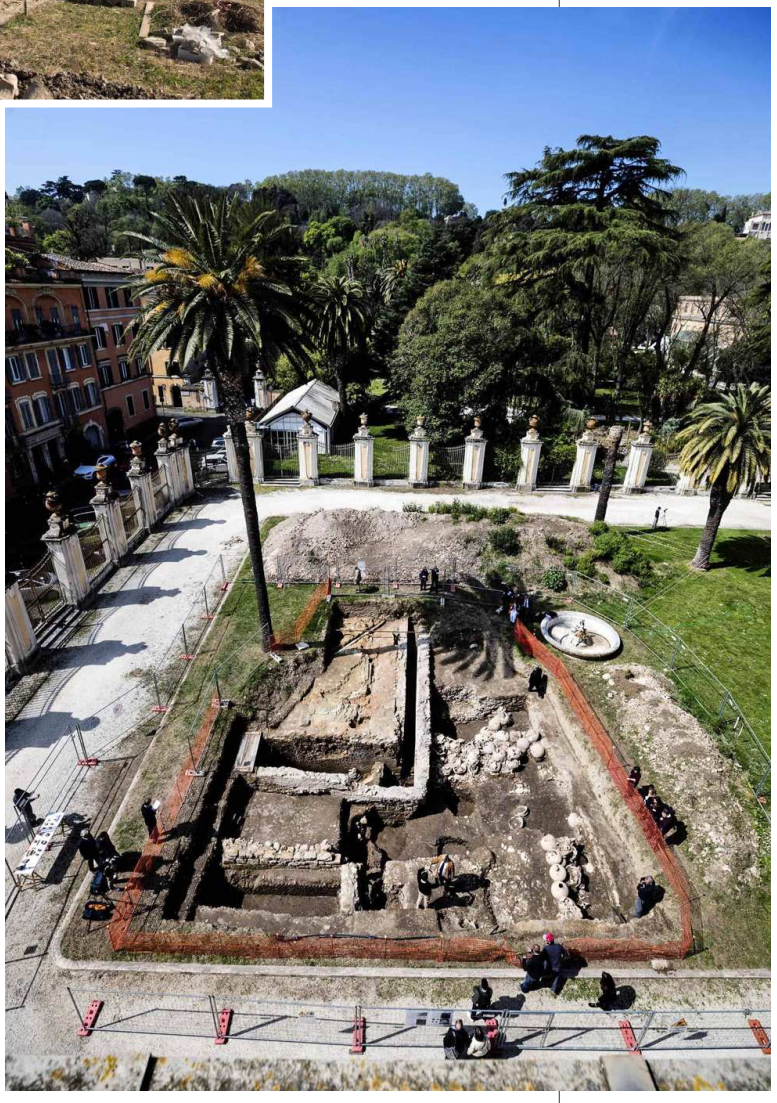
Mining in Potosí, work of 1596 by Theodoor de Bry. Cerro Rico, near the Bolivian city of Potosí, was known as the "mountain that eats men." Alongside, colonial drawings of furnaces for melting silver (huayras) in the Bolivian Andes.

ized episodes may have played a non-negligible role in the pollution of the atmosphere even in more remote times. Some studies carried out in the last two decades have actually highlighted historical periods during which human activities seriously contaminated the air, and not just on a continental scale. One of those periods began in 1532, with the defeat of the Incas by the conquistadors led by Francisco Pizarro. The occupiers began to massively exploit the silver mines of some Peruvian and Bolivian locations, starting the most significant industrial activity on that continent. The methods used by the Spaniards to extract silver from galena, the mineral that most commonly contains it, were first its melting in open furnaces (inefficient and very polluting) and then its amalgamation with mercury. This second

At the beginning of 2019, one of the oldest furnaces used by the Romans was found in the gardens of Palazzo Corsini, located in the center of Rome. [Archeologia Viva, Roma Events]

technique, introduced forty years after the overthrow of the Inca Empire, consisted of reducing the galena ore to powder and adding mercury, which amalgamated with the silver and separated it from the waste material (a subsequent distillation allowed for the recovery of the silver). Both techniques had dramatic effects on the environment, as galena is made up of almost 90% lead and only 1-2% silver. Consequently, the smelting and, above all, the pulverization of that mineral during the Spanish occupation introduced increasing quantities of lead and other harmful elements into the South American atmosphere, to the point of making that long period of intense mining and related metallurgical activity easily recognizable in the ice cores extracted from the Quelccaya Ice Cap (Peru), the second largest glaciated area in the tropics. This glacial site is located about 800 km away from Cerro Rico de Potosí (Bolivia), the largest silver mine in the world and the one that some studies indicate as the point of origin of the metals found in the Peruvian ice. The distance between the two locations gives an idea of the level of pollution that affected those territories in the second half of the sixteenth century (and even later).

At this point it is legitimate to ask oneself whether the anthropogenic trace of lead relating to that period can be observed "today" by a hypothetical contemporary civilization 450 light years (or less) from Earth. Theoretically yes, but only if it has much more powerful investigation instruments than ours. It is estimated that, within a sphere of space with a radius of 450 light-years around the Earth, there are at least

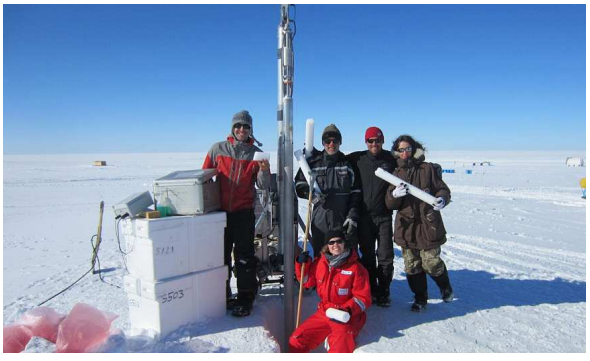


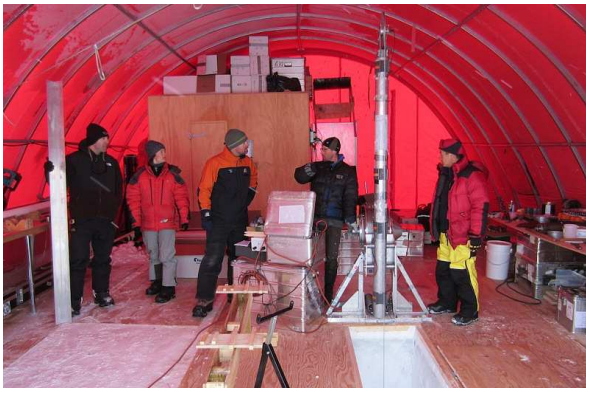
Details of the furnace, provisionally dated between the 1st and 3rd centuries A.D. [Archeologia Viva, Roma Events]

one million stars, which is an excessively large population for any SETI project that wants to observe single targets in search of unnatural signals sent to us after discovering the lead released into the atmosphere by the Spanish Empire.

Can we now exclude even more ancient anthropogenic traces, reaching even further into space today? No, we cannot. On the contrary, it seems that these traces exist, and to find them we have to fly over the whole Middle Ages (not very polluting, from our point of view) and reach the centuries that saw the birth and expansion of the Roman Empire, in particular the centuries in which Rome dominated the ancient world with its presence on three continents. Even that long Roman period was characterized by intense mining activity, aimed at obtaining both silver (often used to mint coins) and lead (used in plumbing, paints and various furnishings).

The production of lead, extracted mainly on the Iberian Peninsula, the Balkans, and the territories of Ancient Greece and Asia Minor, reached a peak of 80,000 tons per year during the golden age of the Roman Empire (2nd century A.D.), a quantity comparable to that reached almost 2000 years later during the Industrial Revolution. In addition to lead and silver, the Romans also produced large quantities of copper (up to 15,000 tons per year), which they often bound to tin to obtain the most resistant bronze. All this mining and metallurgical industriousness, in addition to being polluting by itself, required a considerable consumption of wood and coal. Their combustion, producing the aforementioned carbon dioxide and sulfur dioxide, must have left even more clear traces than those of lead. Of these atmospheric pollutants from imperial Rome, however, no detectable deposits





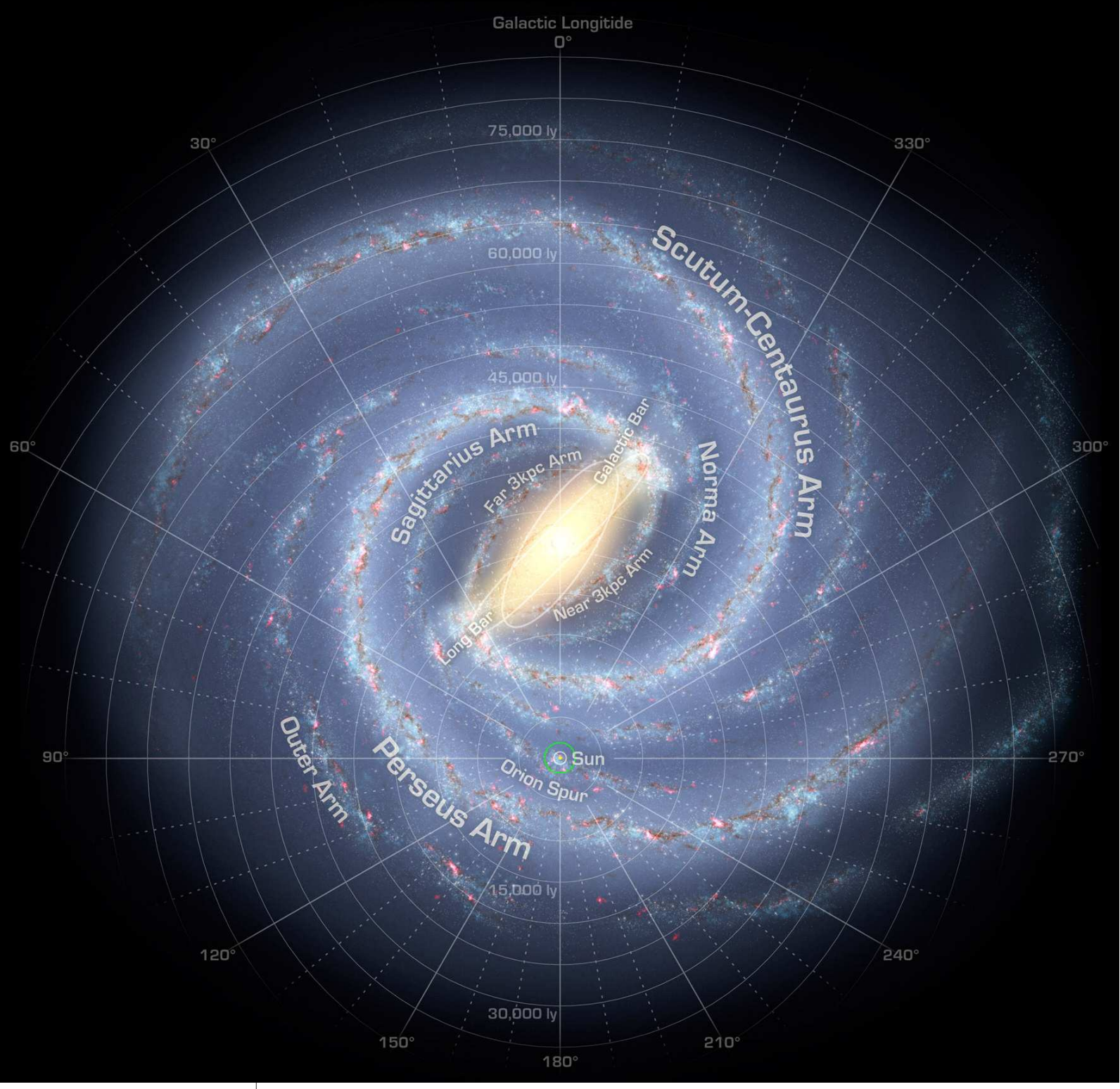
On this page, some snapshots of the North Greenland Eemian Ice Drilling, the project that has given to numerous groups of researchers the opportunity to study variations in climate and atmospheric composition. [NEEM Project Office]

Drilling (NEEM) project showed that, precisely at the developmental peak of those ancient civilizations, significant quantities of greenhouse gases were produced, among which methane stands out. Célia Julia Sapart, a specialist in greenhouse gas emissions and historical climate reconstruction, as well as the leader of the team that conducted the study, said that *"the ice core data show that as far back as the time of the Roman Empire, human activities emitted enough methane gas to have had an impact on the methane signature of the entire atmosphere,"* hence globally.

can be found trapped in glaciers. This is perhaps because, between 250 B.C. and 400 A.D., the European continent went through a phase with an unusually warm climate, known in history as the "Roman Warm Period." Nonetheless, it is likely that for some centuries the atmosphere had shown anomalous abundances of lead and anhydrides. But even if this were not the case, there is certainly another indicator that may have signaled our presence to other civilizations at that same time: methane.

Forest conversion for agriculture and livestock in the Roman Empire, together with the simultaneous large expansion in China of areas cultivated for rice harvesting under the Han dynasty, started a forced increase in the abundance of methane in the atmosphere. A study conducted in 2012 by a team of European and American researchers on ice cores extracted as part of the North Greenland Eemian Ice

Since all this happened almost 2000 years ago, the anthropogenic message carried by the light reflected from the Earth has reached (over the centuries) all the stars up to almost 2000 light years away, which are estimated to be about 50 million. According to new estimates (June 2020) by astronomers at the University of

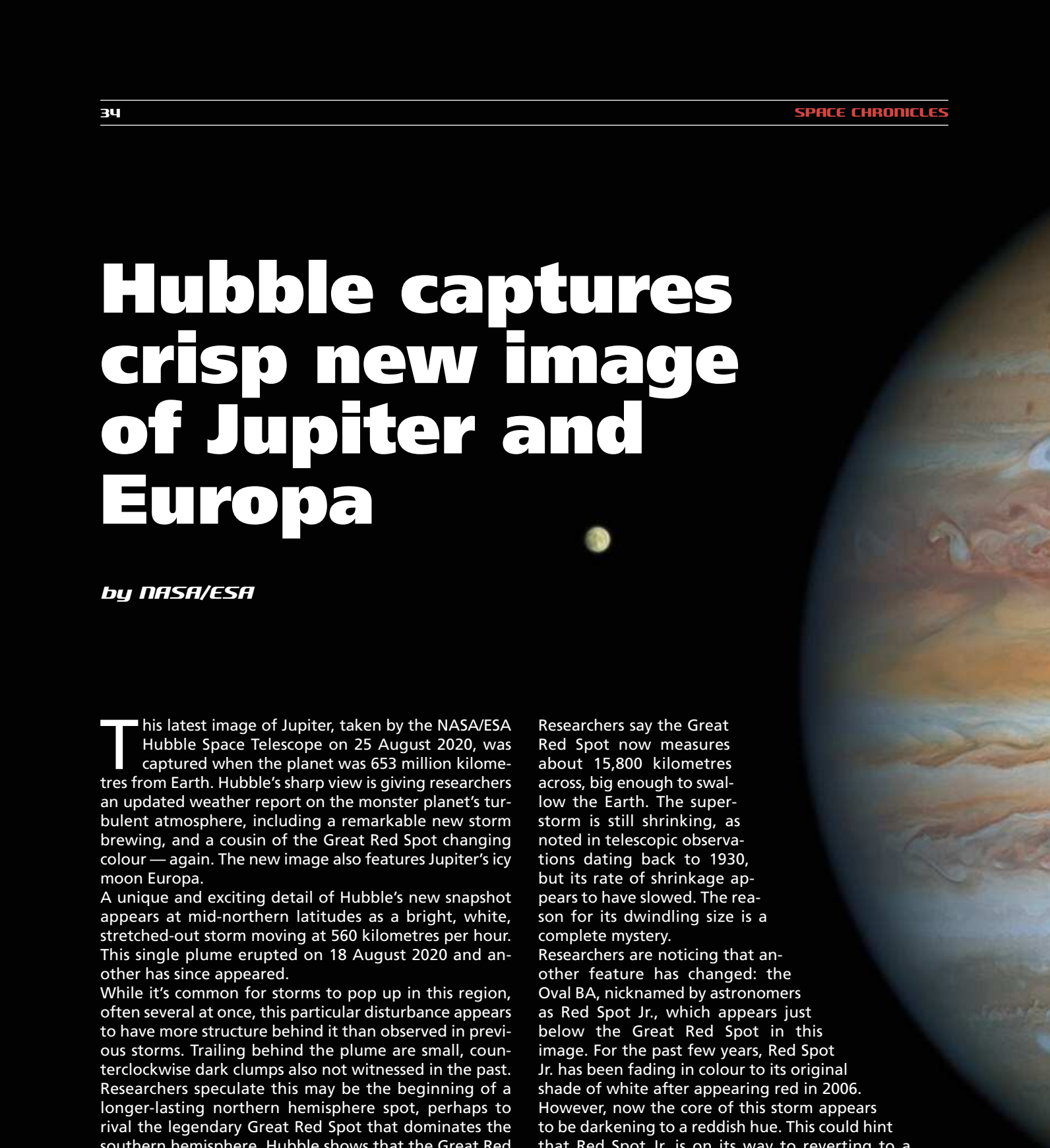


In this representation of the Milky Way, a green circle indicates the region within which the pollution of our atmosphere may have been observed in the last 2000 years. [Robert Hurt (SSC/JPL/Caltech)]

British Columbia, produced with data from NASA's Kepler mission, one Earth-like planet could exist in the Milky Way for every five Sun-like stars. G-type stars, those more similar to the Sun, are about 7% of the total. K-type stars, slightly smaller than the Sun but even more promising from an astrobiological point of view, are about 13% of the total. According to these percentages, within 2000 light years from Earth there could be 2 million planets similar to ours. All uninhabited?

There are those who worry that our first radio transmissions, theoretically having reached about 100 light years away (actually already dispersed in the background noise of the universe), could inform other intelligent life forms of our existence. As we have seen, the traces of ancient terrestrial civilizations have probably already reached far beyond, and their involuntary message, which continues to whiz through the Milky Way, is much easier to discover than a faint radio wave. ■

Hubble captures crisp new image of Jupiter and Europa



by NASA/ESA

This latest image of Jupiter, taken by the NASA/ESA Hubble Space Telescope on 25 August 2020, was captured when the planet was 653 million kilometres from Earth. Hubble's sharp view is giving researchers an updated weather report on the monster planet's turbulent atmosphere, including a remarkable new storm brewing, and a cousin of the Great Red Spot changing colour — again. The new image also features Jupiter's icy moon Europa.

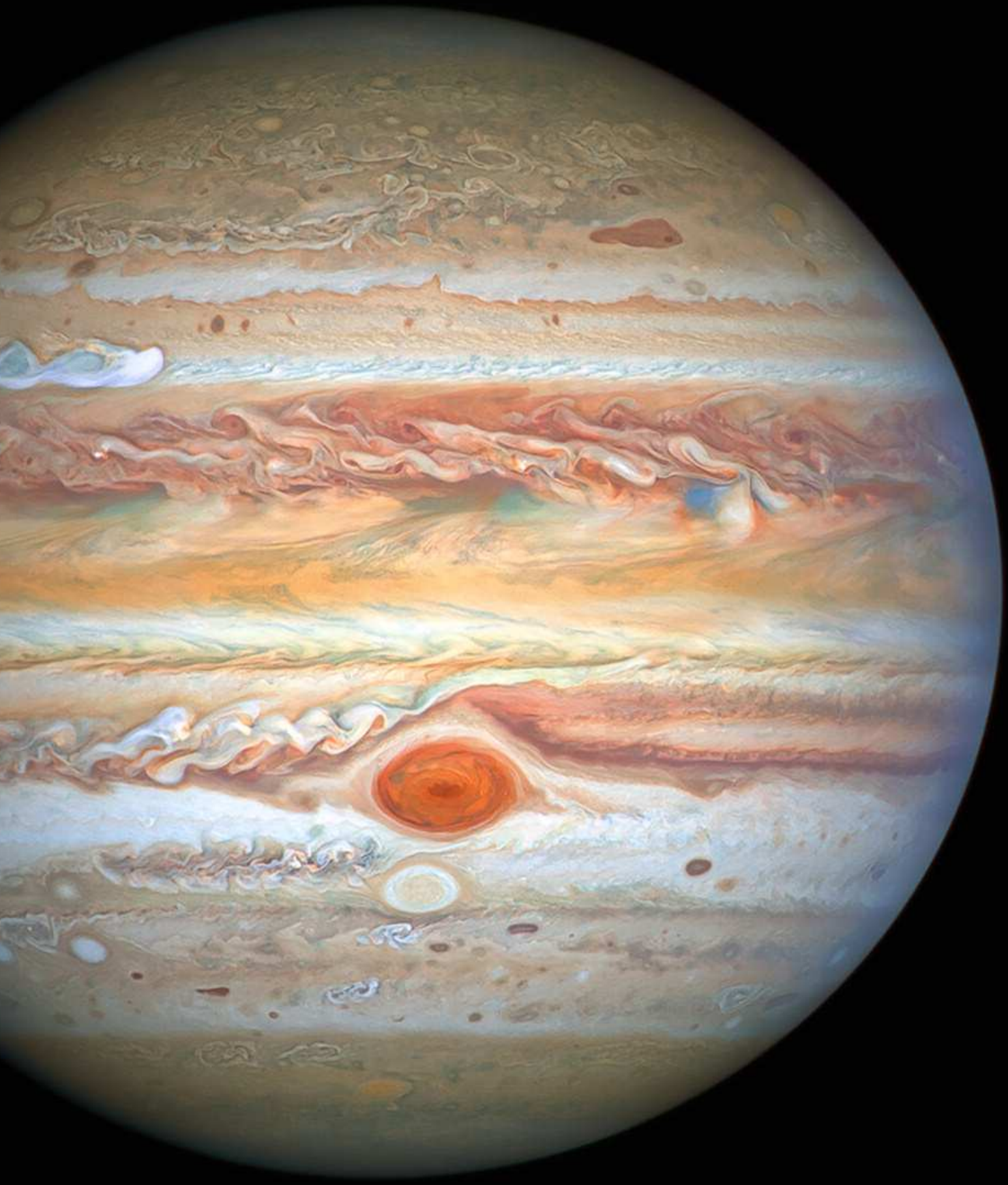
A unique and exciting detail of Hubble's new snapshot appears at mid-northern latitudes as a bright, white, stretched-out storm moving at 560 kilometres per hour. This single plume erupted on 18 August 2020 and another has since appeared.

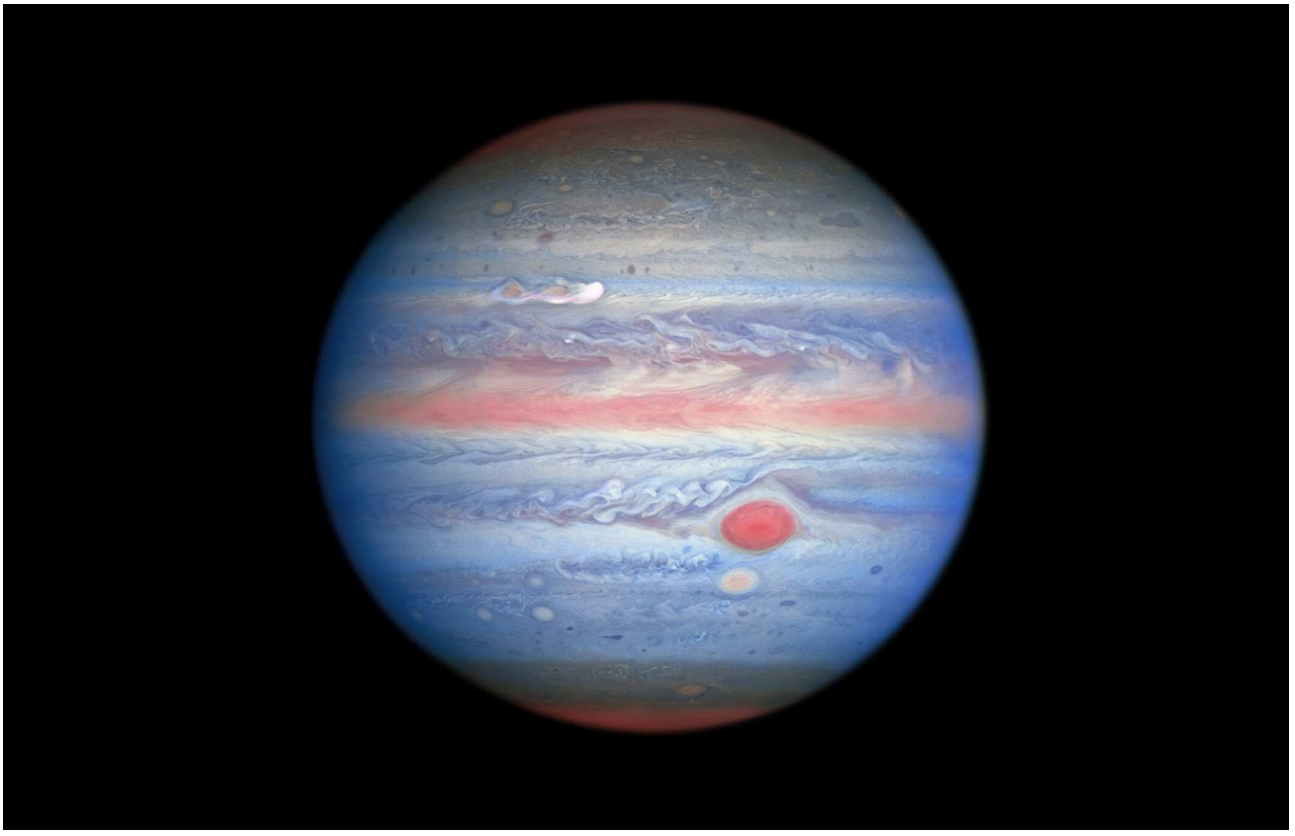
While it's common for storms to pop up in this region, often several at once, this particular disturbance appears to have more structure behind it than observed in previous storms. Trailing behind the plume are small, counterclockwise dark clumps also not witnessed in the past. Researchers speculate this may be the beginning of a longer-lasting northern hemisphere spot, perhaps to rival the legendary Great Red Spot that dominates the southern hemisphere. Hubble shows that the Great Red Spot, rolling counterclockwise in the planet's southern hemisphere, is ploughing into the clouds ahead of it, forming a cascade of white and beige ribbons. The Great Red Spot is currently an exceptionally rich red colour, with its core and outermost band appearing deeper red.

Researchers say the Great Red Spot now measures about 15,800 kilometres across, big enough to swallow the Earth. The superstorm is still shrinking, as noted in telescopic observations dating back to 1930, but its rate of shrinkage appears to have slowed. The reason for its dwindling size is a complete mystery.

Researchers are noticing that another feature has changed: the Oval BA, nicknamed by astronomers as Red Spot Jr., which appears just below the Great Red Spot in this image. For the past few years, Red Spot Jr. has been fading in colour to its original shade of white after appearing red in 2006. However, now the core of this storm appears to be darkening to a reddish hue. This could hint that Red Spot Jr. is on its way to reverting to a colour more similar to that of its cousin.

Hubble's image shows that Jupiter is clearing out its higher-altitude white clouds, especially along the planet's equator, which is enveloped in an orangish hydrocarbon smog.





This video presents two new views of Jupiter taken by the NASA/ESA Hubble Space Telescope. [NASA, ESA, A. Simon (Goddard Space Flight Center), and M. H. Wong (University of California, Berkeley), the OPAL team, and M. Kornmesser (ESA/Hubble)]

Jupiter's icy moon Europa is visible to the left of the gas giant. Europa is already thought to harbour a liquid ocean beneath its icy crust, making this moon one of the main targets in the search for habitable worlds beyond Earth. In 2013 it was announced that the Hubble Space Telescope discovered water vapour erupting from the frigid surface of Europa, in one or more localised plumes near its south pole. ESA's JUpiter ICy moons Explorer, a mission planned for launch in 2022, aims to explore both Jupiter and three of its largest moons: Ganymede, Callisto, and Europa.

Hubble also captured a new multiwavelength observation in ultraviolet/visible/near-infrared light of Jupiter on 25 August 2020, which is giving researchers an entirely new view of the giant planet. Hubble's near infrared imaging, combined with ultraviolet views, provides a unique panchromatic look that offers insights into the altitude and distribution of the planet's haze and particles. This complements Hubble's visible-light picture that shows the ever-changing cloud patterns. ■

A multiwavelength observation in ultraviolet/visible/near-infrared light of Jupiter obtained by the NASA/ESA Hubble Space Telescope on 25 August 2020 is giving researchers an entirely new view of the giant planet. [NASA, ESA, A. Simon (Goddard Space Flight Center), and M. H. Wong (University of California, Berkeley) and the OPAL team]

Science in School aims to promote inspiring science teaching by encouraging communication between teachers, scientists, and everyone else involved in European science education. **Science in School** is published by EIROforum, a collaboration between eight European intergovernmental scientific research organisations, of which ESO is a member. The journal addresses science teaching both across Europe and across disciplines: highlighting the best in teaching and cutting-edge research.

Read more about **Science in School** at: http://www.scienceinschool.org/

Good morning Earth. This is ET radio!

by Michele Ferrara

revised by Damian G. Allis
NASA Solar System Ambassador

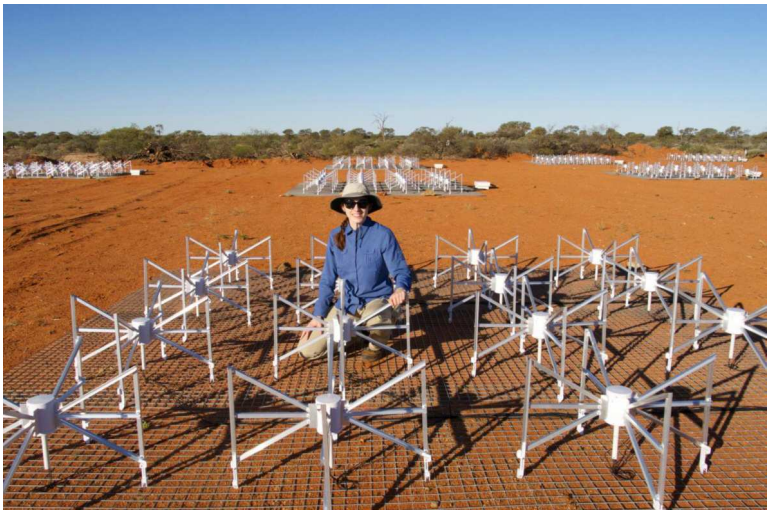
Ground view of one of the 256 grids, each made up of 16 spider-shaped antennas, that make up the Murchison Widefield Array at the Murchison Radio-astronomy Observatory (MRO), 800 km north of Perth, Australia. [Dragonfly Media]

The patchy search for alien civilizations in the Milky Way continues tirelessly. Nearly all surveys are focused on radio waves, and will continue to be in the future, thanks largely to the planning of gigantic networks of radio telescopes, such as the Square Kilometer Array, soon to be built in Australia and South Africa. On the contrary, the search for alien signals in the visible light domain is rather neglected, which could be an error.

In the September-October issue, we reflected on the search for alien technological civilizations, coming to the conclusion that we are very far from having the necessary instruments in place to understand if, in the Milky Way, there are other forms of

life aware of the cosmos that surrounds them. We have seen that, statistically, it is necessary to observe or "listen to" hundreds of millions of stars to have a minimal chance of recording any unnatural signal. Obviously, the situation has not changed in the last two months, but a small step has been taken, as reported in *Publications of the Astronomical Society of Australia* (PASA), where the results of a survey that deserves to be commented on have appeared.

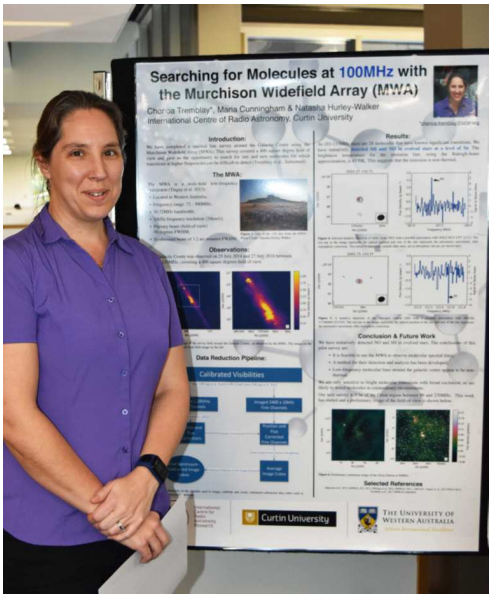
This umpteenth SETI study was conducted by Chenoa Tremblay and Steven Tingay (Curtin University, Australia) using the Murchison Widefield Array (MWA) radio telescope of the Murchison Radio-astronomy Observatory. Between 5 and 23 January 2018, the two Australian researchers tuned the MWA to the 98-128 MHz frequency range and aimed it at an area of sky about 400 square degrees wide, centered on the constellation Vela. That range of frequencies falls within the FM (frequency modulation) band, typically used on Earth for radio broadcasting. When we



The vast expanses of Western Australia are perfect for radio astronomy. In the foreground, one of the 256 MWA grids, spread over several square kilometers. [Pete Wheeler, ICRAR] On the left, other installations, with researcher Nichole Barry present in the grid, making it possible to estimate the size of the antennas. [Ruby Byrne]

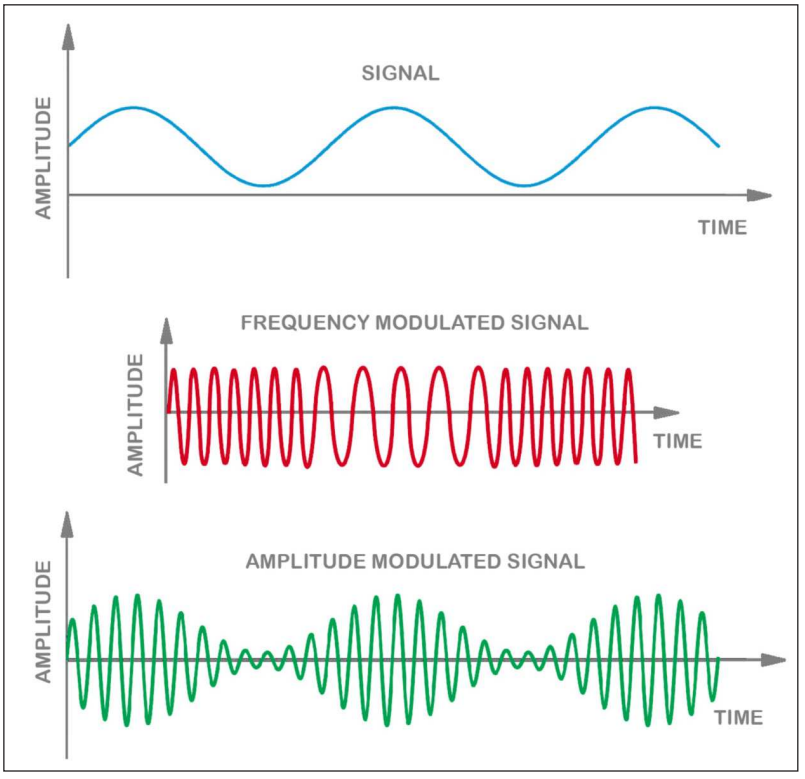
The authors of the survey discussed in this article: Steven Tingay and Chenoa Tremblay. [Curtin University, ICRAR]

listen to our favorite radio station, we are tuned to a frequency in the FM band, and probably to one used by Tremblay and Tingay to search for alien broadcasts. The two researchers simultaneously listened to over 3,000 channels with a resolution of 10 kHz, sufficient to distinguish any powerful alien transmission sent from the planets closest to us among those in orbit around the approximately 10 million stars framed by the MWA. Each single observation (listening) of the entire probed area lasted only 5 minutes, for a total integration time of 17 hours. However small this period may seem, the survey conducted by Tremblay and Tingay is to date the deepest and most extensive carried out in low frequency. As Trembley herself pointed out: *"The MWA is a unique telescope, with an extraordinarily wide field-of-view that allows us to observe millions of stars simultaneously. We observed the sky around the constellation of Vela for 17 hours, looking more than 100 times broader and deeper than ever before."*



Despite this, all the channels listened to were silent. Here is what Tingay said about this, not at all surprised by the negative result: *"With this dataset, we found no technosignatures — no sign of intelligent life. As Douglas Adams noted in* The Hitchhiker's Guide to the Galaxy, *'space is big, really big'. And even though this was a really big study, the amount of space we looked at was the equivalent of trying to find something in the Earth's oceans but only searching a volume of water equivalent to a large backyard swimming pool. Since we can't really assume how possible alien civilizations might utilize technology, we need to search in many different ways. Although there is a long way to go in the search for extraterrestrial intelligence, telescopes such as the MWA will continue to push the limits — we have to keep looking."*

Tingay is not new to these performances. Previously, he had probed similar frequency ranges by pointing the MWA towards the Galactic Center and the Galactic Anticenter regions, both with the same results: absolute silence (excluding interference of terrestrial origin). In fact, although the MWA has been installed in a remote place (Boolardy, Western Australia) and is protected from radio signals emitted by inhab-

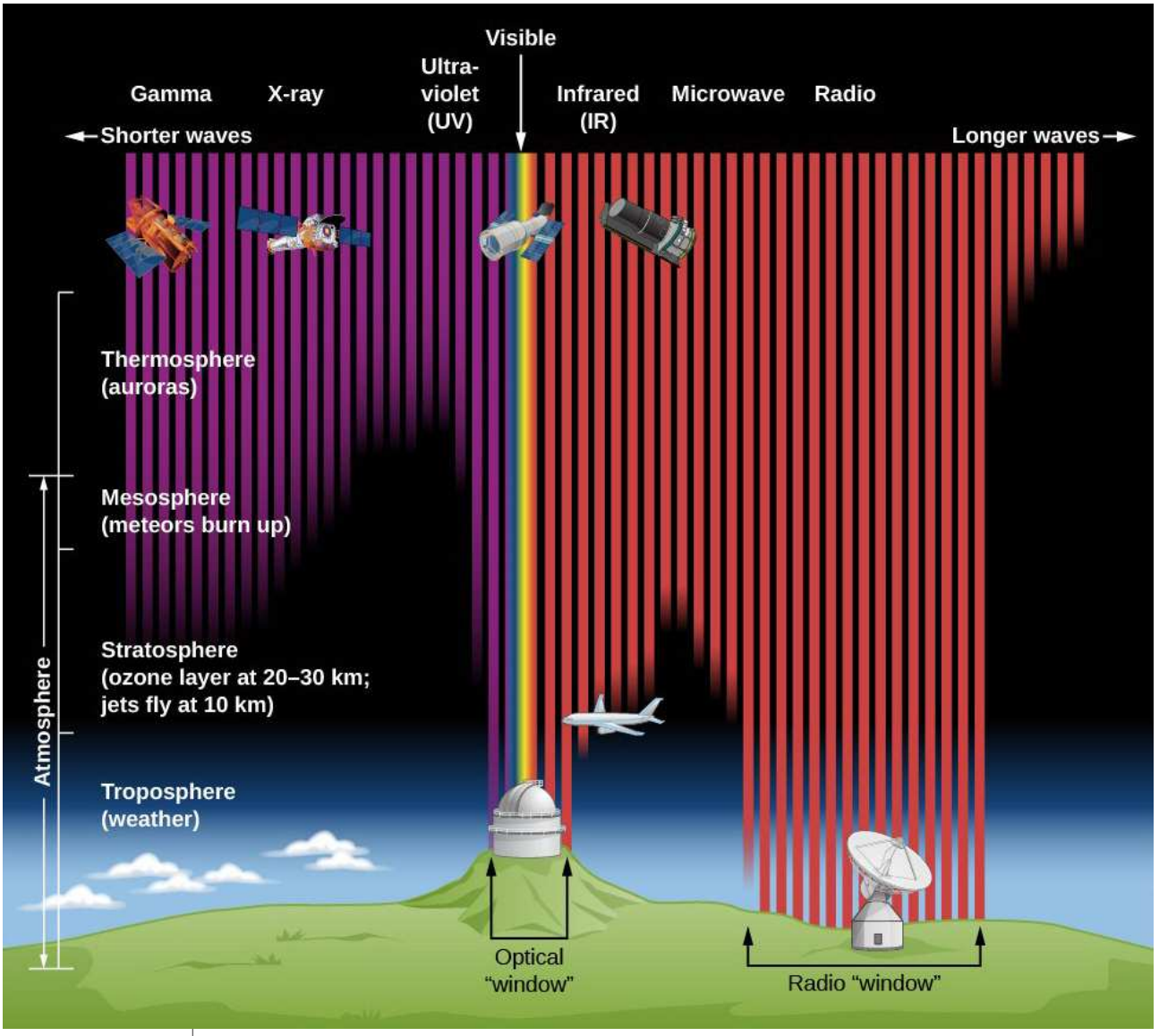


By modulating a carrier radio wave with a suitably produced signal, we can have two types of resulting signals: one modulated in frequency (FM) and one modulated in amplitude (AM). Tremblay and Tingay searched for FM signals from a large region of the sky centered on the constellation Vela, but with negative results. Below, an animation showing the two types of radio signals.

ited centers, interference may nevertheless occur that researchers must remove with appropriate tricks. However, interference as a whole limits the potential of the instrument by more than 30%. Therefore, one wonders the reason for looking for a hypothetical alien transmission precisely in the FM band, occupied by thousands of radio stations (mostly commercial), with all of the complications that this entails. To understand that choice, we must start from the very nature of radio waves. They are a subset of the electromagnetic spectrum and, by convention, are divided into bands. Depending on the bands used, radio waves can be employed to transmit data, sounds, images and any other element that can be converted with a transducer (encoder, microphone, camera, etc.) into electrical signals of variable amplitude. These electrical signals are, *de facto*, the information you want to transmit. To transmit it, however, it is necessary to generate the so-called "carrier wave" (or simply "carrier") with an oscillating circuit, of which the frequency, amplitude and phase are known. If we listened to a radio station that transmits only the carrier, we could at most hear a single note or a continuous noise.

Instead, we hear voices and music, and this is because the carrier has been modulated with the electrical signals generated by the transducer. The addition of information causes the regular sinusoidal shape of the carrier to undergo a change in amplitude (AM = amplitude modulation) or in frequency (the aforementioned FM = frequency modulation). The signal thus obtained is amplified and radiated through an antenna in the form of electromagnetic radiation.

AM was the first method used to transmit radio programs, but achieving quality reception was often difficult due to adverse weather conditions or sources of electric fields of various kinds that produced alter-



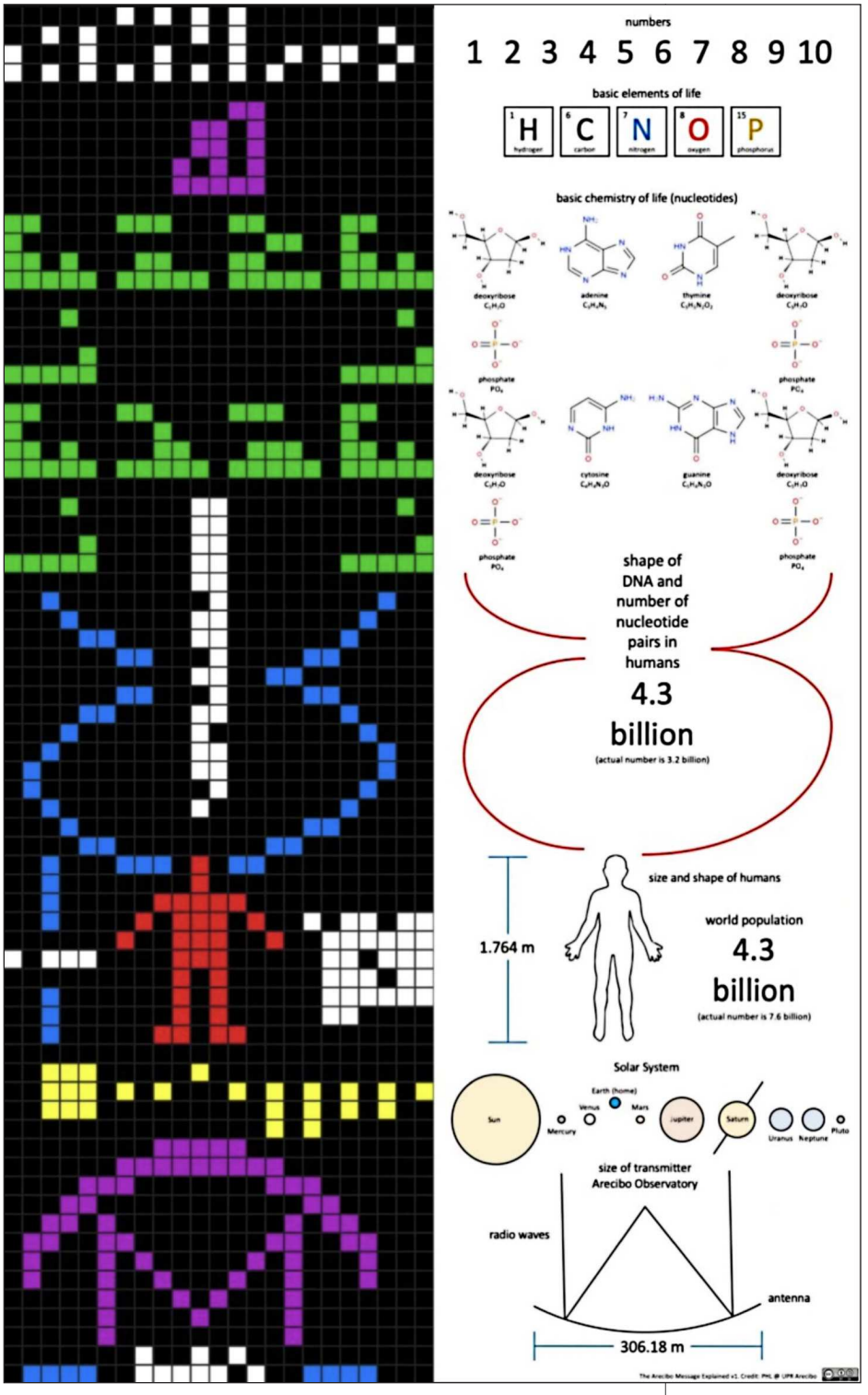
Infographic of the electromagnetic spectrum, which includes the levels of penetration of the various forms of radiation in the Earth's atmosphere.

ations in the amplitude of the sent radio wave. A valid alternative was devised in the 1930s by the American engineer Edwin Howard Armstrong, who developed the frequency modulation technique that is both much less subject to interference and more efficient in various applications. This is why any alien technological civilization could be expected to choose to broadcast on FM rather than other radio bands. This, of course, is a terrestrial opinion, although the electromagnetic spectrum in general can be considered a universal means of investigation and communication. We don't know why Tremblay and Tingay decided to center their latest survey on the constellation Vela. In their article published in PASA, they emphasize the presence in this region of six known exoplanets, at which their listening was particularly attentive. However, as already mentioned, the survey included about 10 million stars, and therefore likely millions of other unknown exoplanets. It would not have been easy to find the source of any FM

signal not directly attributable to that handful of known exoplanets. Tuning into the right channel, identifying the transmitter in space, and receiving the message are all actions that require a precise level of cognitive and technological development that the broadcaster (the alien civilization) should consider typical of the receiver (us). How could the alien civilization be certain of our ability to perform those actions?

Why should anyone who takes the initiative to attempt a contact choose a path that requires the possible interlocutor to use complex techniques and processes so that the message sent is received and understood? Furthermore, considering the immense distance that would surely divide two galactic technological civilizations, and the very long times that would then elapse between each back and forth, would it even make sense to start a conversation? Each reply to a previous message could find an interlocutor with ideas and intentions different from the original ones. They may not even know the previous contents of the conversation or no longer be able to recognize our messages.

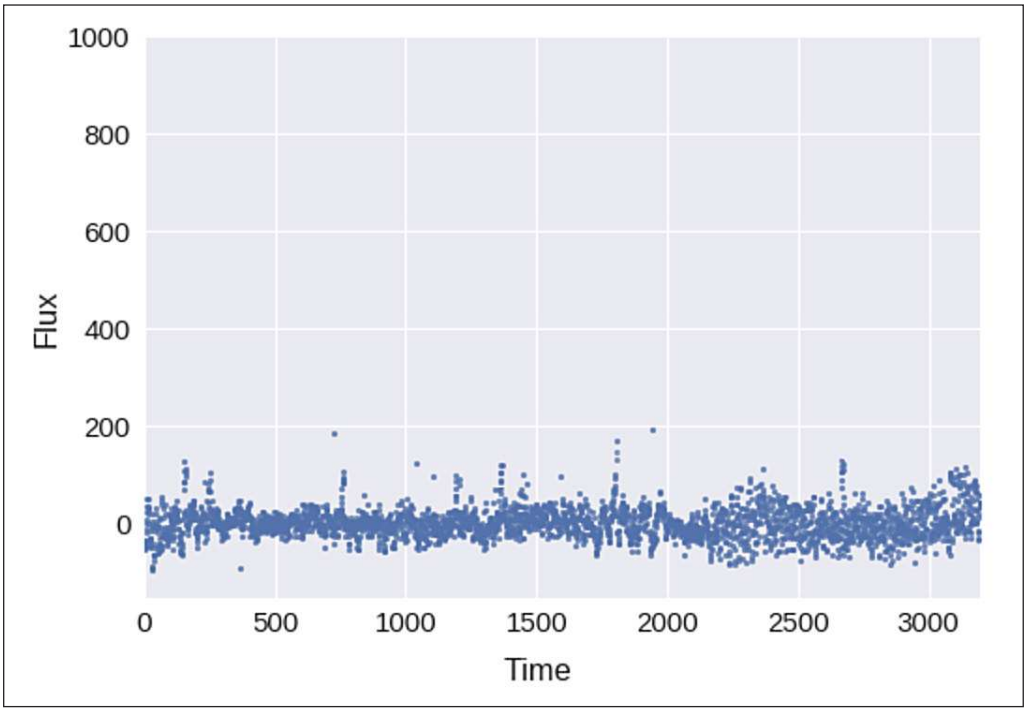
Those who deal with these issues inevitably ask themselves why the members of a technological civilization should seek contact (active or passive, it does not matter) with a similar civilization on a very distant planet. The answer is obvious: to understand if they are alone in their galaxy or in the universe. Although we humans inhabit this wonderful planet in the company of



In the previous page, the famous message from Arecibo sent to unknown beings on November 16, 1974. Its content is excessively anthropocentric and childish. After that naive undertaking, another thirty messages were sent with other antennas to individual stars. One of them, the Altair (Morimoto – Hirabayashi) Message, has already reached its destination. The rest will reach different stars between 2022 and 2450.

about nine million other living species (of which only 14% are identified), we feel alone as if we were a single organism detached from all others. Discovering around another star someone more similar to us than other terrestrial animals and plants whould mitigate our sense of solitude, as well as have heavy implications of a scientific, philosophical and religious nature.

Based on the principle of mediocrity (discussed in the July-August issue), this sentiment should be typical of all technological civilizations, or at least those that attempt contact. Therefore, given the insuperable difficulties of an interstellar conversation and considering that the primary purpose should be to simply be sure of the existence of the other, the content of the message sent or expected could be the equivalent of a simple "you are not alone" or "we are here too." More than anything else, it should be an altruistic act of one civilization towards another civilization, of which the sender of the message sensed the existence by analyzing a planetary atmosphere. Since we are not yet able to let others know that they are not alone, we just have to look for messages of that type arriving at Earth, hoping they will be receivable with our instruments. If they were sent with more advanced technologies than ours, they could go unnoticed or unheard. Our own technological development does not trend towards the kind of simplified messaging that would be most desirable for a successful contact attempt. Therefore, is it not perhaps more reasonable to assume that those who decide to send a message into space would want to do so in a part of the electromagnetic spectrum that is essential to intelligent life – so essential as to be the reason for a species' basic awareness of the universe itself? We obviously refer to the light visible to the eyes of ourselves and other evolved animals, light that generally occupies the 400-700 nanometer range of the electromagnetic spectrum. It is difficult to imagine life forms that look at the stars, and therefore the universe, in a totally different light than our own. For example, can intelligent life develop on a planet by seeing the environment in which it evolves in gamma, X or UV rays? A simple "no" may be enough. Similarly, it could not do so by

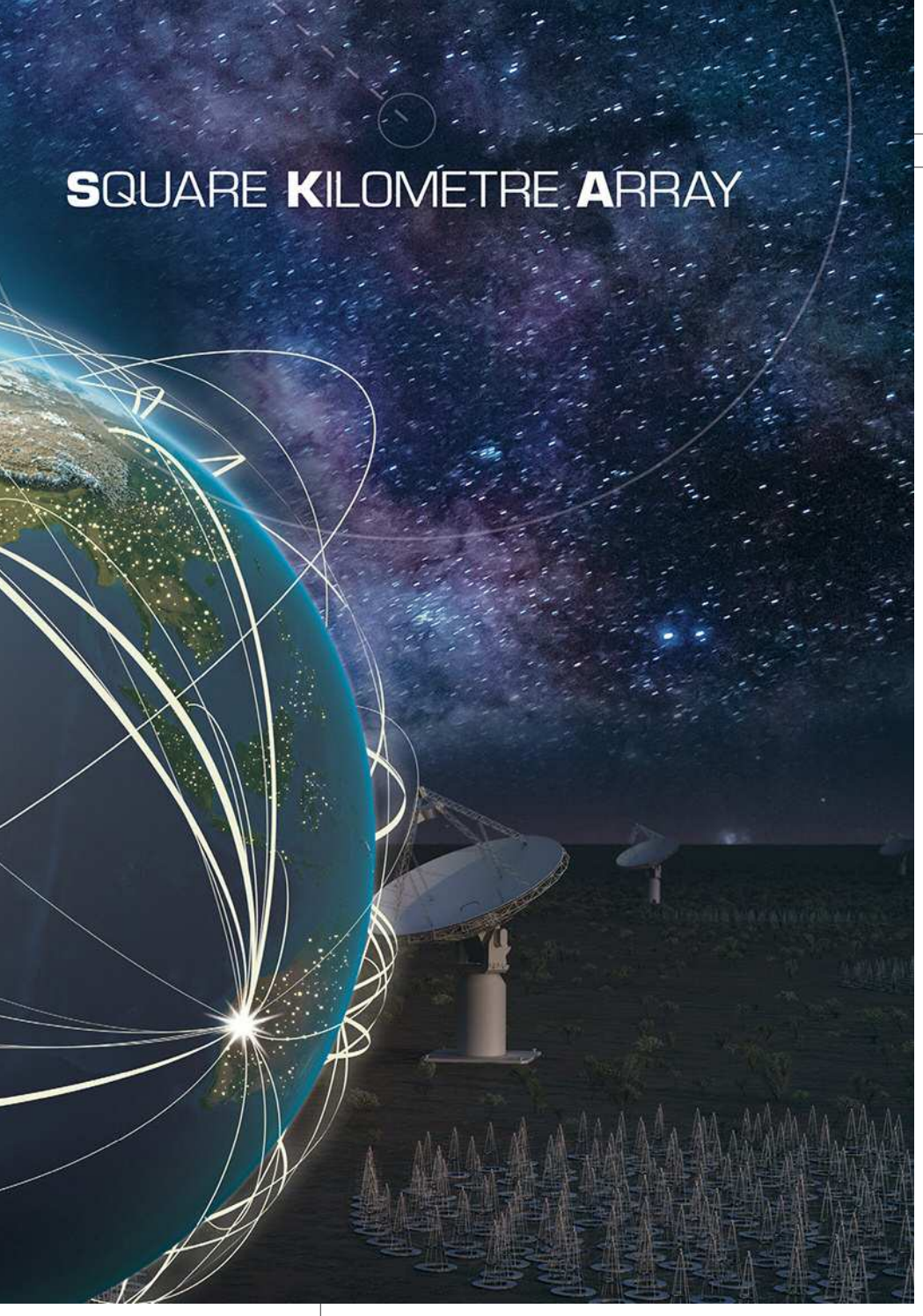


A hypothetical light curve of a star in which an artificial signal has been added, here represented by short peaks emerging from the scatter of the measurements. In a real scenario, the intensity and duration of the peaks, as well as the intervals that separate them, could hide an alien message.

seeing radio waves or microwaves emitted by everything that exists on the rocky surface of its planet of origin, as inanimate objects in a terrestrial-like environment do not habitually emit such radiation. In the first case, life would not exist; in the second case, it would not have the slightest awareness of what surrounds it (although, at most, an exception could be made for infrared radiation).

It is, therefore, not a gamble to say that the only certainty an alien civilization could have about us is that we are able to distinguish variations in intensity (and perhaps also in color) of so-called visible light. That same alien civilization could also reasonably assume that, if we are curious enough, we would have already invented the telescopes and other devices useful for recording starlight, and that we are therefore able to perceive small variations in the light radiation arriving at our planet. On the contrary, ET would have no certainty of our knowledge of radio waves, which are not as essential to the evolution of intelligent life. So why look for frequency modulation or in radio bands at all? The obstinacy of most SETI projects in investigating the ra-

After seven years of design and prototyping, the International Center for Radio Astronomy Research (ICRAR) has completed preparations for the construction of SKA, which will begin in 2021 and will give new impetus to SETI projects.



dio domain is truly amazing. Perhaps it would be preferable to launch more diversified surveys, massively including visible frequencies in these studies – a choice that could restore meaning to the dozens of optical telescopes that lie unused in less advanced professional observatories.

An alien civilization could send a periodic message in visible light through powerful lasers powered by large photovoltaic systems much more efficient than ours.

From a conceptual point of view, we earthlings already have an idea of how to make a transmitter of that type. A slightly more advanced civilization may have already built it. Having enough power available, ET would be able to send light pulses into space that would add to the brightness of the parent star, causing small variations in magnitude in the entire visible spectrum (white light) or in certain colors. By suitably modulating the impulses, a sequence "easily" distinguishable from the variations attributable to natural phenomena would be generated. What can we expect to see in that star's light curve? Probably short and simple numerical sequences (it is reasonable that ET knows how to count), represented by impulses of varying duration, intensity and amplitude. If the sole purpose of the message is to inform us that we are not alone, the beginning of some basic numerical sequences may be enough, where each subsequent number is represented with light pulses of a duration or intensity proportionally higher than the previous one.

We can perhaps expect the most basic 1, 2, 3, 4, 5, 6, 7... or a sequence of the prime numbers 2, 3, 5, 7, 11, 13, 17... or the Fibonacci sequence 1, 1, 2, 3, 5, 8, 13... all probably known by a technological alien civilization. The preference of one sequence over the others may depend on the amount of energy required to produce and keep the signal transmitted for a long time. Intuitively, higher numbers would require more energy, and for this reason the sequences might appear short but repeated. Long sequences, as well as being excessively expensive, might also be less legible. Curiously, the duration of the intervals between successive pulses could also be revealing, representing, for example, itself a numerical sequence.

Waiting for more targeted SETI projects, let's turn on the radio – you never know what might happen! ■

A spectacular supernova time-lapse

by NASA/ESA

The NASA/ESA's Hubble Space Telescope has tracked the fading light of a supernova in the spiral galaxy NGC 2525, located 70 million light-years away. Supernovae like this one can be used as cosmic tape measures, allowing astronomers to calculate the distance to their galaxies. Hubble captured these images as part of one of its major investigations, measuring the expansion rate of the Universe, which can help answer fundamental questions about our Universe's very nature. The supernova, formally known as SN2018gv, was first spotted in mid-January 2018. Hubble began observing the brilliant brightness of the supernova in February 2018 as part of the research program led by lead researcher and Nobel Laureate Adam Riess of the Space Telescope Science Institute (STScI) and Johns Hopkins University, in Baltimore, USA. The Hubble images center on the barred spiral galaxy NGC 2525, which is located in the constellation of Puppis in the Southern Hemisphere.

The supernova is captured by Hubble in exquisite detail within this galaxy in the left portion of the image. It appears as a very bright star located on the outer edge of one of its beautiful swirling spiral arms. This new and unique time-lapse of Hubble images created by the ESA/Hubble team shows the once bright supernova initially out-

Pictured in the background is part of the captivating galaxy NGC 2525 (above). Located nearly 70 million light-years from Earth, this galaxy is part of the constellation of Puppis in the southern hemisphere. Together with the Carina and the Vela constellations, it makes up an image of the Argo from ancient greek mythology. On the left, a brilliant supernova is clearly visible in the image. The supernova is formally known as SN2018gv and was first spotted in mid-January 2018. [ESA/Hubble & NASA, A. Riess and the SH0ES team. Ack: Mahdi Zamani]

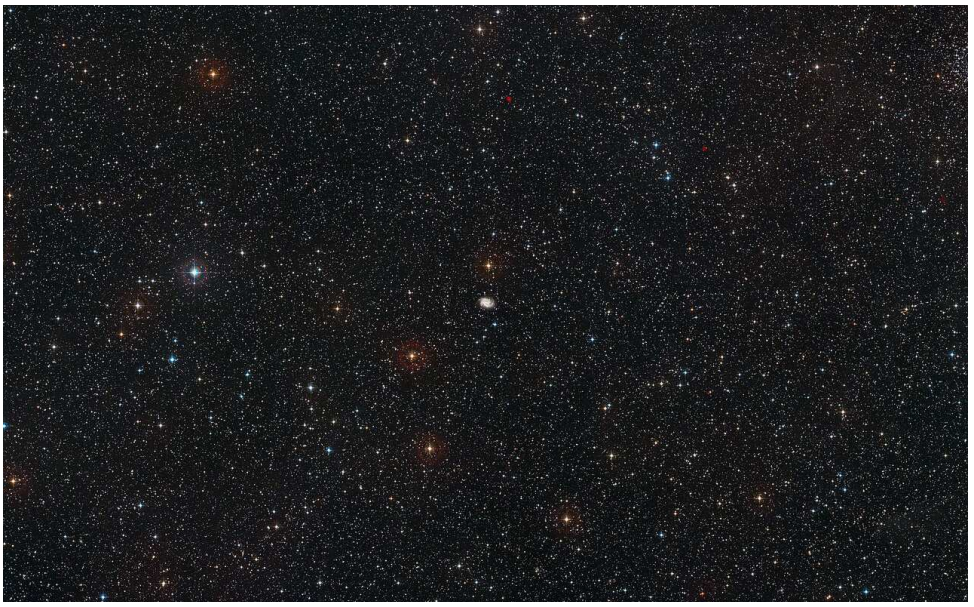
shining the brightest stars in the galaxy, before fading into obscurity during the year of observations. This time-lapse consists of observations taken over the course of one year, from February 2018 to February 2019.

"No Earthly fireworks display can compete with this supernova, captured in its fading glory by the Hubble Space Telescope," shared Riess of this new time-lapse of the supernova explosion in NGC 2525. Supernovae are powerful explosions which mark the end of a star's life. The type of supernova seen in these images, known as a Type Ia supernova, originate from a white dwarf in a close binary system accreting material from its companion star. If the white dwarf reaches a critical mass (1.44 times the mass of our Sun), its core becomes hot enough to ignite carbon fusion, triggering a thermonuclear runaway process that fuses large amounts of oxygen and carbon together in a matter of seconds. The energy released tears the star apart in a violent explosion, ejecting matter at speeds up to 6% the speed of light and emitting huge amounts of radiation.

Type Ia supernovae consistently reach a peak brightness of 5 billion times brighter than our Sun before fading over time.

Because supernovae of this type produce this fixed brightness, they are useful tools for astronomers,

known as 'standard candles', which act as cosmic tape measures. Knowing the actual brightness of the supernova and observing its apparent brightness in the sky, astronomers can calculate the distance to these grand spectacles and therefore their galaxies. Riess and his team combined the distance measurements from the supernovae with distances calculated using variable stars known as Cepheid variables. Cepheid variables pulsate in size, causing periodic changes in brightness. As this period is directly related to the star's brightness, astronomers can calculate the distance to them: allowing them to act as another standard candle in the cosmic distance ladder. Riess and his team are interested in accurately measuring the distance to these galaxies since it helps them better constrain the expansion rate of the Universe, known as the Hubble constant. This value accounts for how fast the Universe is expanding depending on its distance from us, with more distant galaxies moving faster away from us. Since it launched, Hubble Space Telescope has helped dramatically improve the precision of the Hubble constant. Results from the same observing program led by Riess have now reduced the uncertainty of their measurement of the Hubble constant to an unprecedented 1.9%.



Pictured here is the region surround-ing NGC 2525. Located nearly 70 million light-years from Earth, this galaxy is part of the constellation of Puppis in the southern hemisphere. [ESA/Hubble, Digitized Sky Survey 2. Ack: D. De Martin]

Further measurements of NGC 2525 will contribute to their goal of reducing the uncertainty down to 1%, pinpointing how fast the Universe is expanding.

A more accurate Hubble constant may uncover clues about the invisible dark matter and mysterious dark energy, responsible for accelerating the Universe's rate of expansion. Together this information can help us understand the history and future fate of our Universe. A supermassive black hole is also known to be lurking at the centre of NGC 2525. Nearly every galaxy contains a supermassive black hole, which can range in mass from hundreds of thousands to billions of times the mass of the Sun. ■

This video shows a unique time-lapse of the supernova in galaxy NGC 2525. The supernova is captured by Hubble in exquisite detail within this galaxy in the lower left portion of the frame. It appears as a very bright star located on the outer edge of one of its beautiful swirling spiral arms. This new and unique time-lapse of Hubble images shows the once bright supernova initially outshining the brightest stars in the galaxy, before fading into obscurity during the telescope's observations. This time-lapse consists of observations taken over the course of one year, from February 2018 to February 2019. [ESA/Hubble & NASA, M. Kornmesser, M. Zamani, A. Riess and the SH0ES team]

COURMAYEUR
MONT BLANC

Région Autonome Vallée d'Aoste
Regione Autonoma Valle d'Aosta

skyway MONTE BIANCO

Monte Bianco Cableways: the dream of bringing man closer to the mountains and the sky.

A structure challenging the laws of nature, where the view from above seems to go on forever.
An idea making it possible to broaden horizons and overcome borders.
All of this is Skyway Monte Bianco.

www.montebianco.com/en

Ritchey-Chrétien

- SCHOTT Supremax 33 optics
- optical diameter 355 mm
- useful diameter 350 mm
- focal length 2800 mm
- focal ratio f/8
- 18-point floating cell
- customized focuser

Dall-Kirkham

- SCHOTT Supremax 33 optics
- optical diameter 355 mm
- useful diameter 350 mm
- focal length 7000 mm
- focal ratio f/20
- 18-point floating cell
- Feather Touch 2.5” focuser

Cassegrain

- SCHOTT Supremax 33 optics
- optical diameter 355 mm
- useful diameter 350 mm
- focal length 5250 mm
- focal ratio f/15
- 18-point floating cell
- Feather Touch 2.5” focuser