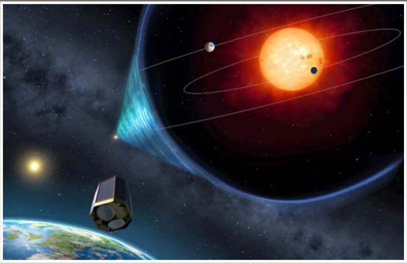
THE FREE MULTIMEDIA MAGAZINE THAT KEEPS YOU UPDATED ON WHAT IS HAPPENING IN SPACE

FREE ASTRONOMY magazine

Bi-monthly magazine of scientific and technical information ✶ September-October 2017 issue



The PLATO mission, a decisive step

The pulsars in NICER's sights

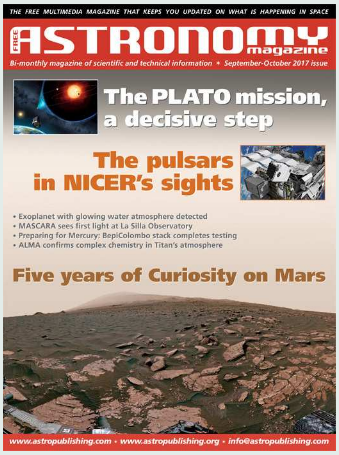
- Exoplanet with glowing water atmosphere detected
- MASCARA sees first light at La Silla Observatory
- Preparing for Mercury: BepiColombo stack completes testing
- ALMA confirms complex chemistry in Titan's atmosphere

Five years of Curiosity on Mars

FREE ASTRONOMY magazine

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

September-October 2017



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

S U M M A R Y

4 ***The pulsars in NICER's sights***
For the last few months, NASA has been running a new mission that promises to answer a question that has been nagging us for decades: 'How large is a neutron star?'. The instruments that researchers had available before now only provided partial, approximate answers, but with the help of the NICER X-ray...

12 ***Exoplanet with glowing water atmosphere detected***
Scientists have discovered the strongest evidence to date for a stratosphere on a planet outside our solar system, or exoplanet. A stratosphere is a layer of atmosphere in which temperature increases with higher altitudes. "This result is exciting because it shows that a common trait of most of the atmospheres in...

16 ***MUSE instrument discovers new way to fuel black holes***
An Italian-led team of astronomers used the MUSE (Multi-Unit Spectroscopic Explorer) instrument on the Very Large Telescope (VLT) at ESO's Paranal Observatory in Chile to study how gas can be stripped from galaxies. They focused on extreme examples of jellyfish galaxies in near-by galaxy clusters, named after...

20 ***The PLATO mission, a decisive step***
The Kepler space telescope brought us so close to discovering planets just like the Earth. Now the European Space Agency has started implementing an instrument that will harvest Kepler's legacy and help to provide a credible answer to the question most often asked by those who watch the night sky...

28 ***MASCARA sees first light at La Silla Observatory***
In June 2016, ESO reached an agreement with Leiden University to site a station of MASCARA at ESO's La Silla Observatory in Chile, taking advantage of the excellent observing conditions of the southern hemisphere skies. This station is now made its first successful test observations. The MASCARA station...

32 ***Hubble spots clumps of new stars in a distant galaxy***
When it comes to the distant universe, even the keen vision of NASA's Hubble Space Telescope can only go so far. Teasing out finer details requires clever thinking and a little help from a cosmic alignment with a gravitational lens. By applying a new computational analysis to a galaxy magnified by a gravitational...

34 ***Preparing for Mercury: BepiColombo stack completes testing***
ESA's Mercury spacecraft has passed its final test in launch configuration, the last time it will be stacked like this before being reassembled at the launch site next year. BepiColombo's two orbiters, Japan's Mercury Magnetospheric Orbiter and ESA's Mercury Planetary Orbiter, will be carried together...

36 ***Five years of Curiosity on Mars***
Five years have passed since NASA's Curiosity rover landed near Mount Sharp on Mars. All along this period, Curiosity has driven over 10 miles, taking over 200,000 images. In this symbolic tribute to the mission, we introduce you some of the latest spectacular Martian landscapes created by merging...

46 ***ALMA confirms complex chemistry in Titan's atmosphere***
Saturn's largest moon, Titan, is one of our solar system's most intriguing object and Earth-like bodies. It is nearly as large as Mars and has a hazy atmosphere made up mostly of nitrogen with a smattering of organic, carbon-based molecules, including methane (CH_4) and ethane (C_2H_6). Planetary scientists...

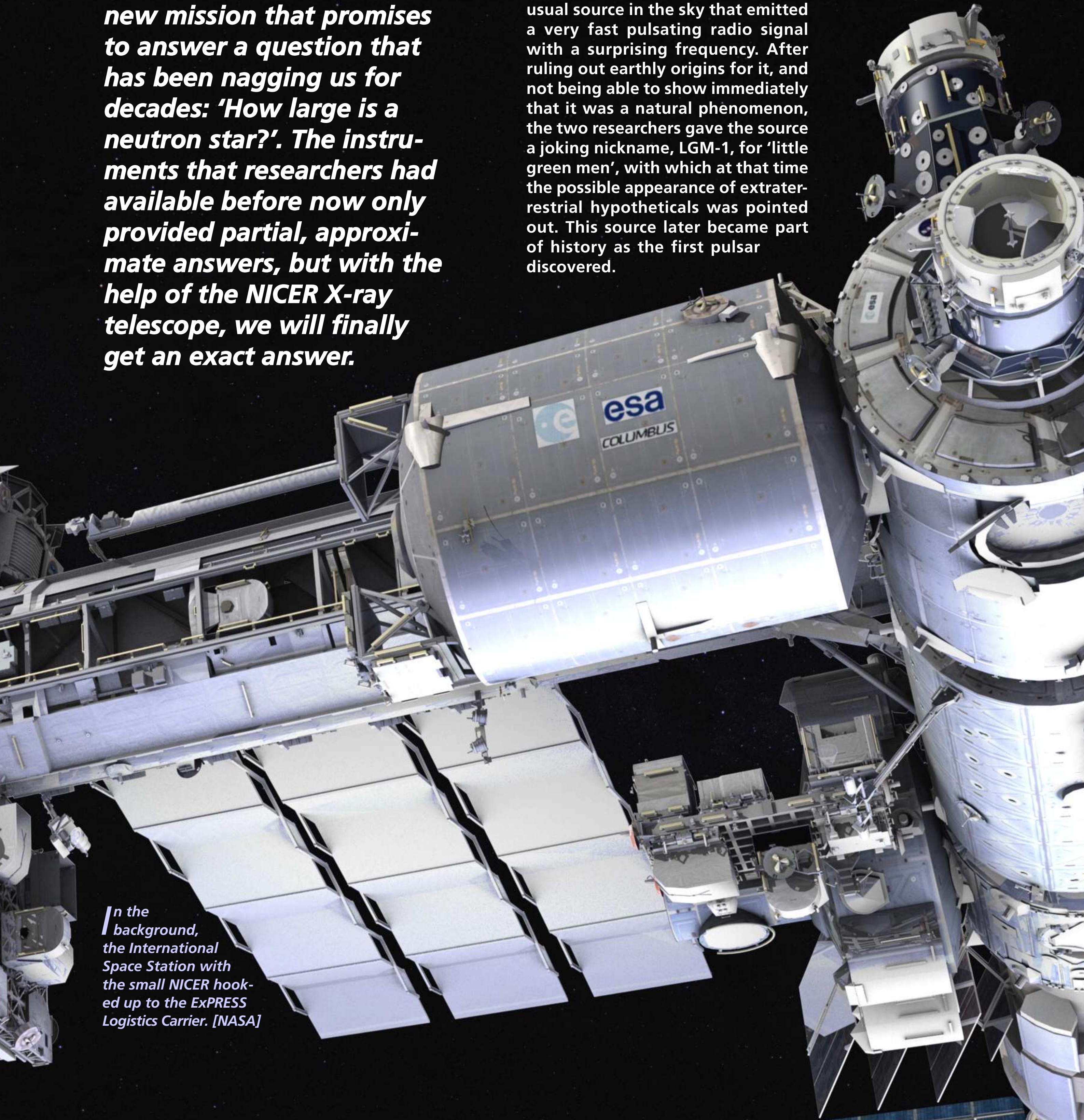
48 ***The Adaptive Optics Facility sees first light***
The Adaptive Optics Facility (AOF) is a long-term project on ESO's Very Large Telescope (VLT) to provide an adaptive optics system for the instruments on Unit Telescope 4 (UT4), the first of which is MUSE (the Multi Unit Spectroscopic Explorer). Adaptive optics works to compensate for the blurring effect of the Earth's...

The pulsars in NICER's sights

by Michele Ferrara

For the last few months, NASA has been running a new mission that promises to answer a question that has been nagging us for decades: 'How large is a neutron star?'. The instruments that researchers had available before now only provided partial, approximate answers, but with the help of the NICER X-ray telescope, we will finally get an exact answer.

In late November 50 years ago, Jocelyn Bell Burnell and Antony Hewish discovered a quite unusual source in the sky that emitted a very fast pulsating radio signal with a surprising frequency. After ruling out earthly origins for it, and not being able to show immediately that it was a natural phenomenon, the two researchers gave the source a joking nickname, LGM-1, for 'little green men', with which at that time the possible appearance of extraterrestrial hypotheticals was pointed out. This source later became part of history as the first pulsar discovered.



In the background, the International Space Station with the small NICER hooked up to the ExPRESS Logistics Carrier. [NASA]

('Pulsar' is a portmanteau of the words 'pulse' and 'star'.) Pulsars are nothing other than neutron stars, or super-dense remnants of supernovae generated by stars with an initial mass at least 7 to 20 times larger than the Sun. Most of the neutron stars known today (a few thousand) fall into the pulsar classification for purely geometric reasons: the beams of radiation they hurl into space from their magnetic poles intersect our line of sight. This condition makes it easier to find them. Actually, almost all neutron stars emit a periodic pulsating signal, but it does not necessarily face the Earth. Although it has been half a century since their discovery, we don't know much about neutron stars. Their diameter is known only vaguely (perhaps up to 20 km), so their mass is therefore uncertain as well (estimates vary from 1.4 to more than 2 times more than the Sun), not to mention the exotic state of the material inside them, which is subject to awesome pressure that increases sharply from the surface to the core, producing layers of varied, unimaginable densities. The tools in existence so far have not been able to provide measurements with enough time and spectral resolution to analyse the physics inside neutron stars. The most painstaking studies done to date have

Above, the SpaceX CRS-11 Falcon 9 rocket lifts off on June 3, 2017 from Launch Complex 39A at NASA's Kennedy Space Center sending a Dragon spacecraft on the company's 11th commercial re-supply services mission to the International Space Station. The payload includes NICER. Left, NICER mission overview. The payload also includes a technology demonstration called the Station Explorer for X-ray Timing and Navigation Technology (SEXTANT) which will help researchers to develop a pulsar-based space navigation system. [NASA]

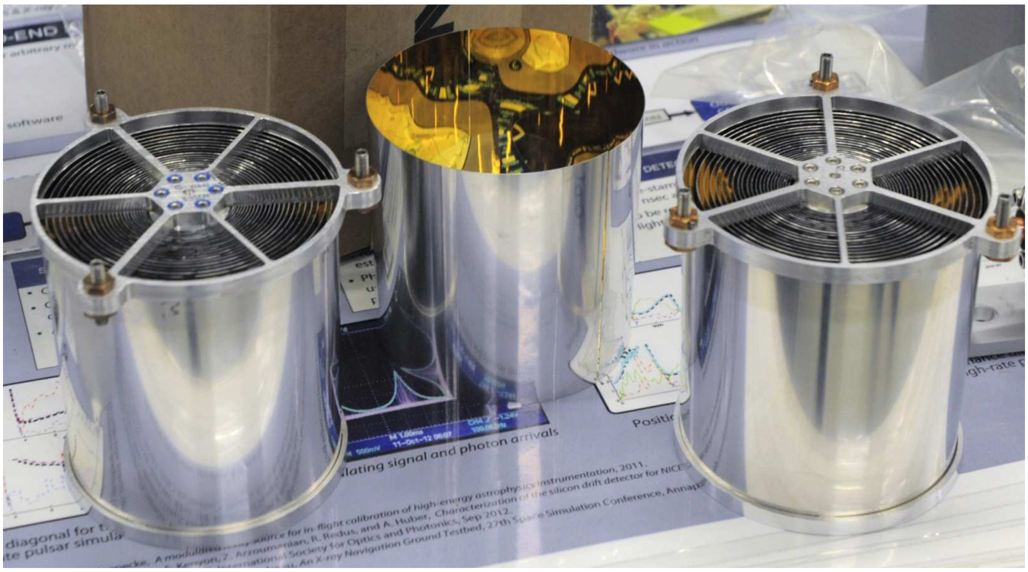
NICER Mechanical Engineer Steven Kenyon (left) and GPS and Star Tracker Camera Engineer Eric Rogstad (right) prepare NICER for shipment to Kennedy Space Center in Florida. The payload has been deployed on the International Space Station (ISS). [Barbara Lambert] Below, this video explains some of what's known about neutron stars and previews NASA's Neutron star Interior Composition Explorer mission (NICER). [NASA]

only provided an incomplete picture of what lies beneath the surface: a thin layer of atomic nuclei permeated by a flow of electrons; next, a thicker, denser layer of ions immersed in superfluid neutrons; then, a liquid outer nucleus of superconducting protons; and finally, an inner nucleus about which we know nearly nothing and for which various mathematical models offer widely varying scenarios, from superfluids dominated by neutrons to degenerate matter composed of quarks.

Since Walter Baade and Fritz Zwicky hypothesized the existence of neutron stars in 1934, it was thought that those extreme heavenly bodies were composed solely and uniformly of neutrons, because in addition to smashing the atomic nuclei, the enormous pressure would have pushed the electrons against the protons, generating neutrons. Today we know that things are more complicated and that some thorny issues remain unsettled, first among them the relationship between mass and diameter. This situation is now destined to be resolved thanks to a new NASA mission that began operating in June with a nominal duration of 18 months.

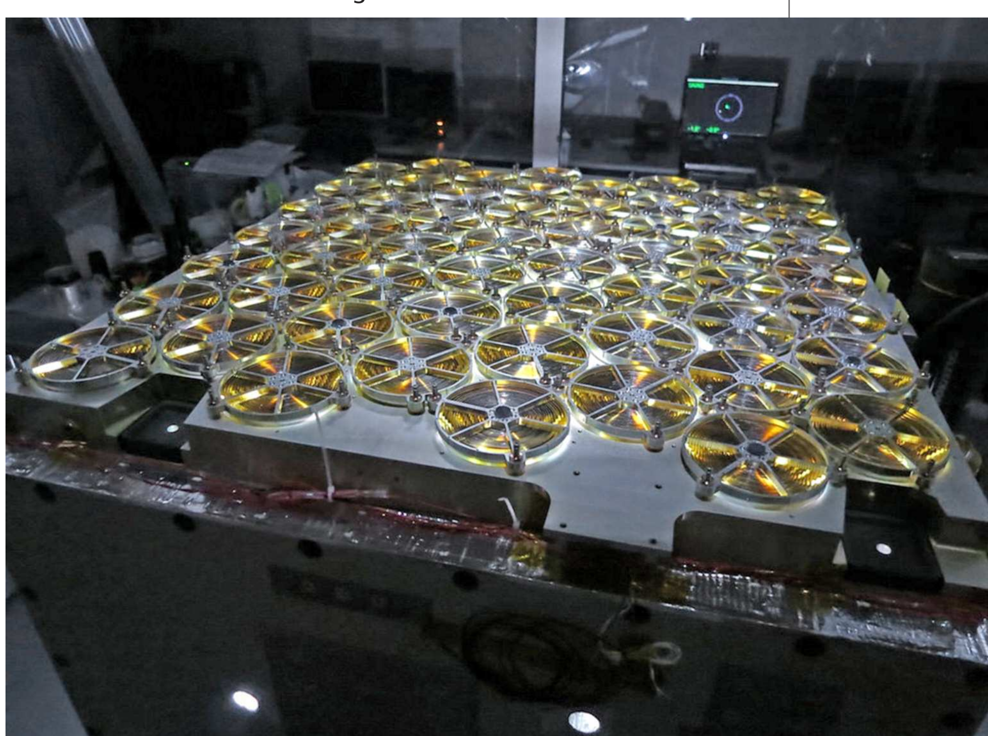
It is called NICER, for Neutron star Interior Composition ExploreR. The acronym is a little forced, but the full name makes the mission's purpose clear.

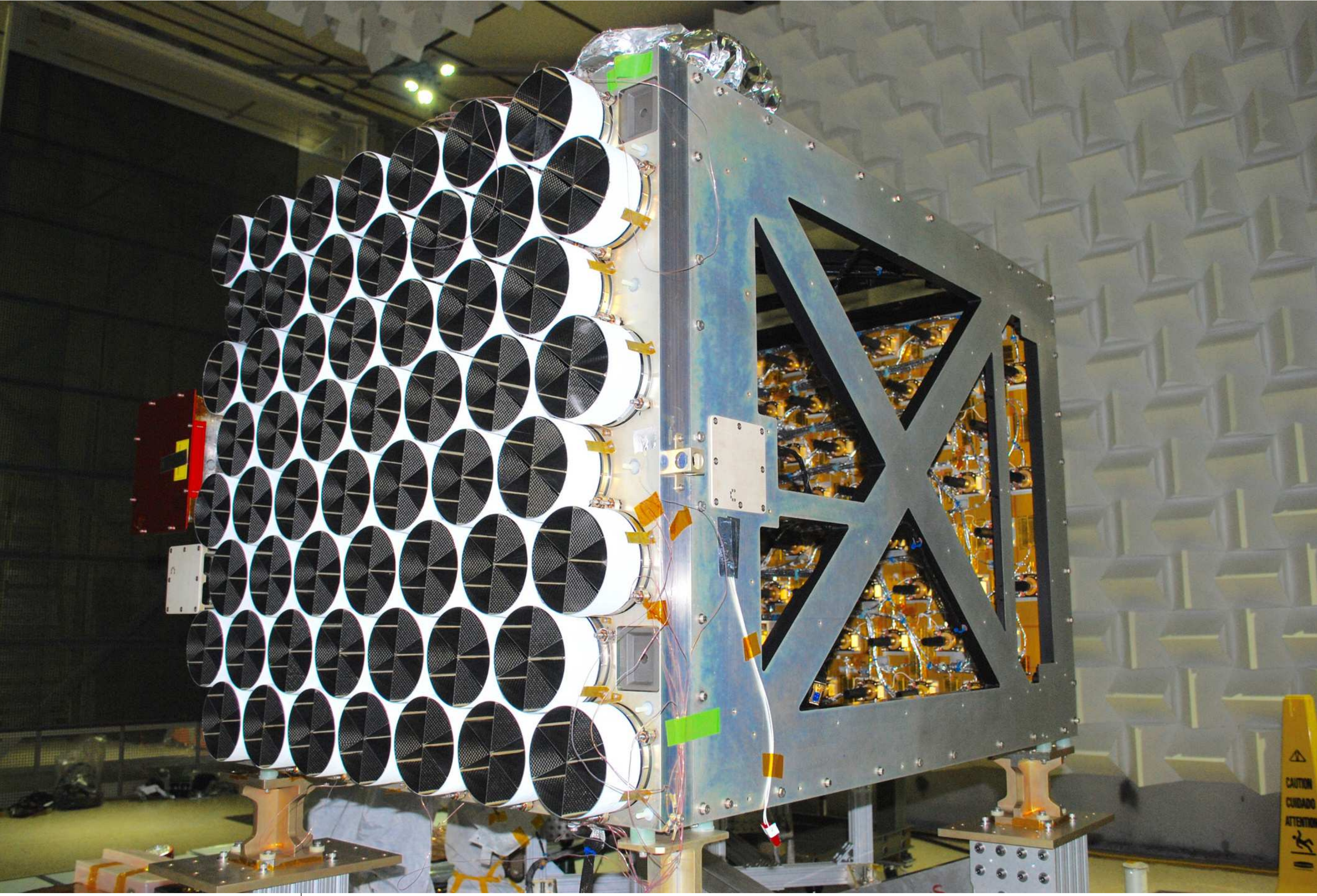
Launched on 3 June with a SpaceX Falcon 9 rocket, NICER is a space telescope for soft X-rays (0.2-12 keV), which, rather than orbiting around the Earth by itself, does this while hitched to the International Space Station, to take advantage of



Left and below, work in progress on single X-ray concentrators and the NICER concentrator plate. [NASA]

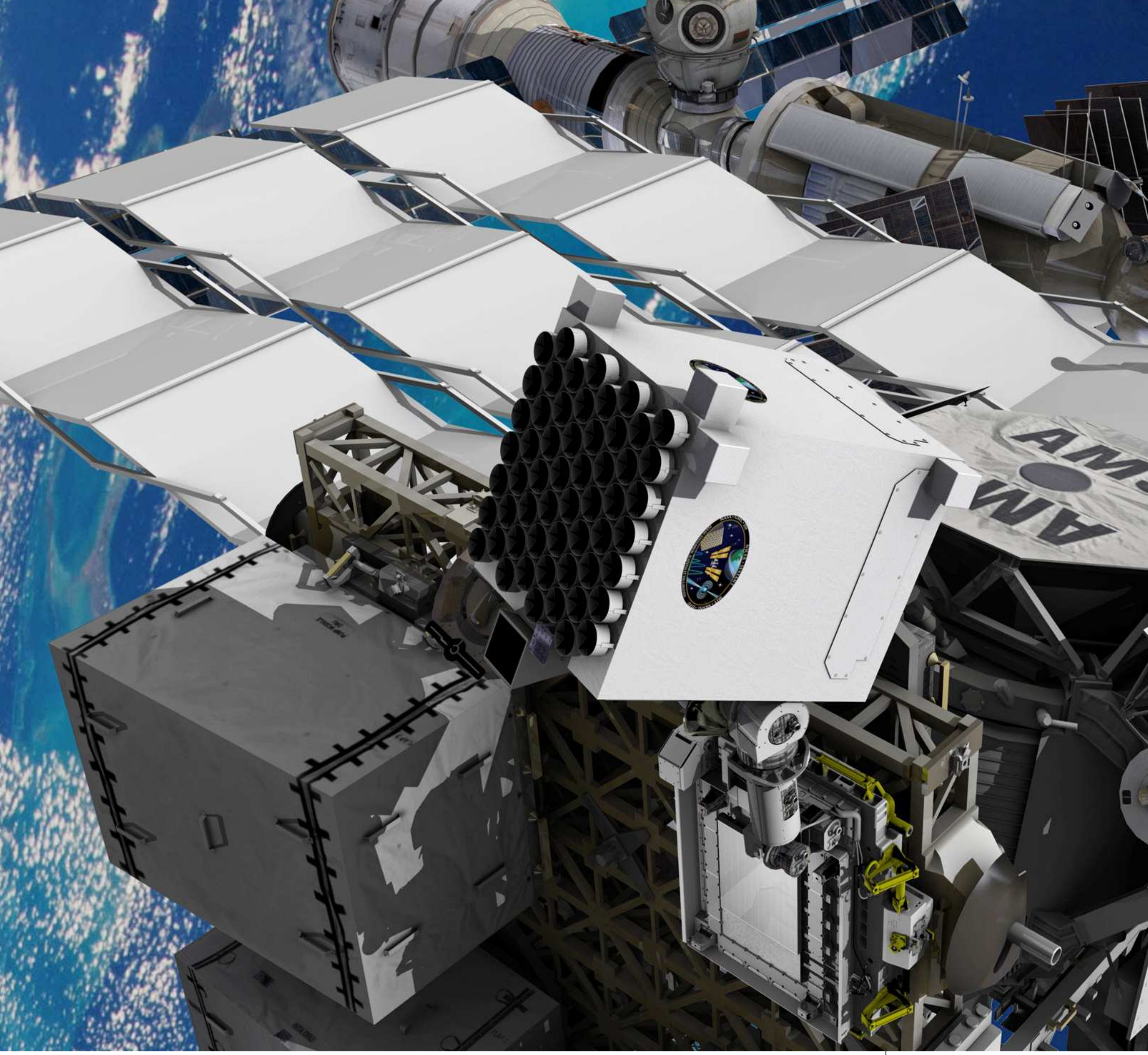
existing structures and equipment, which significantly reduced the cost of the mission. A little larger than a dishwasher, NICER contains the X-ray Timing Instrument (XTI), an array of 56 X-ray concentrators (called XRCs), connected with silicon drift detectors (SDDs). Every XRC collects photons on a surface of about 50 cm^2, from an area of the sky 15 arc minutes wide, and diverts them to the SDDs. They register each individual X-ray photon, precisely measure its energy (from the ionization level produced in the detector material) and record its arrival time just as precisely. Before looking at why these data are crucial to the goals of the study of neutron stars, let's make a quick digression about X-ray concentrators so that we understand in broad outline how they work. For all practical purposes, these tools are mirror telescopes, but since X-ray photons have very high frequencies and thus a high penetrating power, common reflecting mirrors cannot be used to deflect them towards the focal plane; instead of reflecting off the surfaces of those mir-





The aligned collection of 56 X-ray concentrator optics (XRC) and silicon drift detector, that represents the heart of the NICER's X-ray Timing Instrument (XTI). Right, this video shows the robotic installation of NICER on ExPRESS Logistics Carrier 2, initial deployment, precise point tests and more. [NASA]

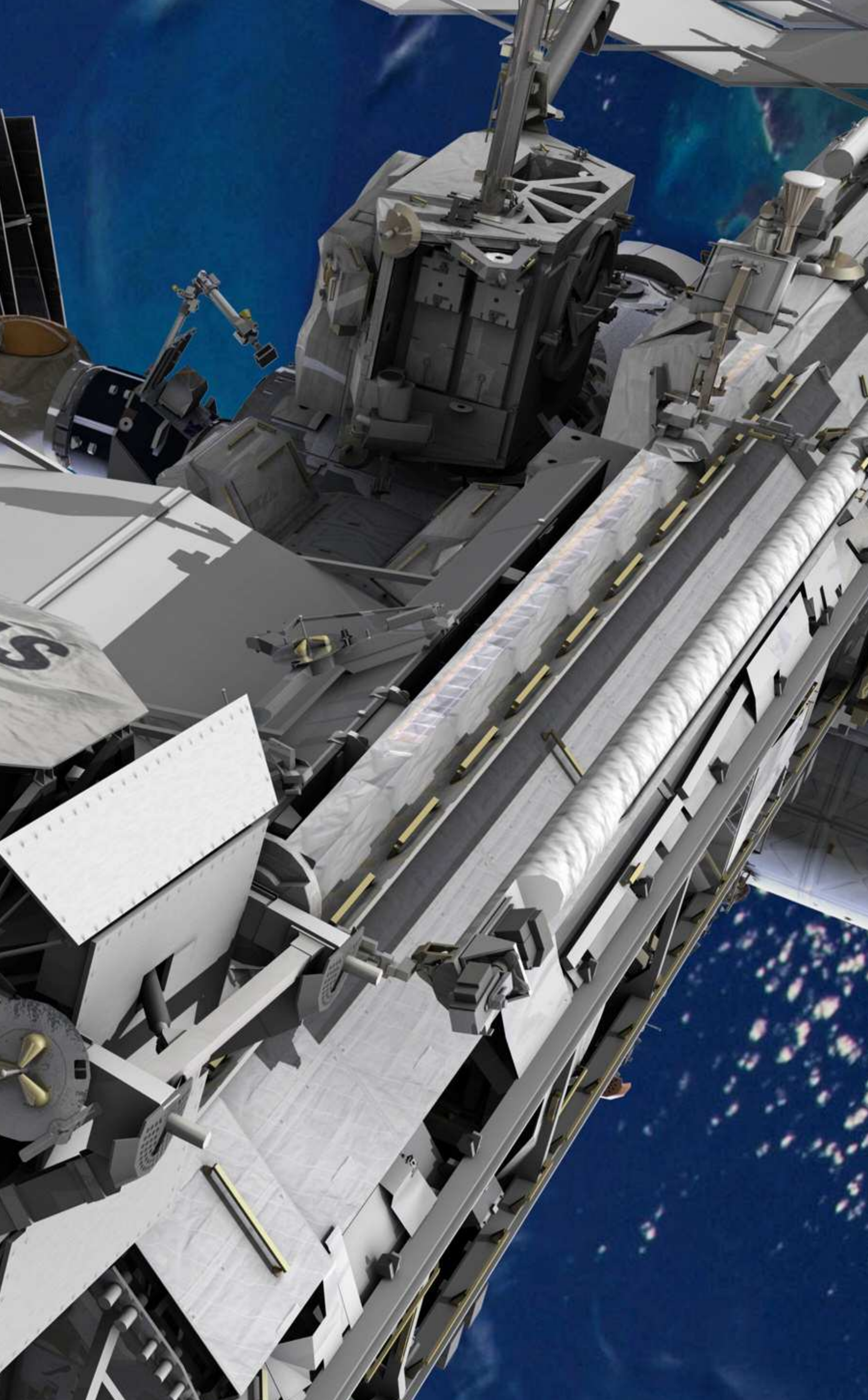
rors, in fact, they would simply pass through them. Researchers solved this problem by using metal foil sheets folded to form truncated hollow cones, whose slanted inner surfaces make the X-ray photons coming in from space hit them at a very low incident angle (almost parallel). A couple of 'bounces' on two truncated cones with an increasing inclination are enough to cluster the X-ray photons on a focal plane. Since a single sheet of metal foil (or a sequence of 2-3 sheets), even with a large diameter, collects very few X-ray photons, researchers use 'mirrors' with



many concentric sets of sheets, which all together can collect most of the X-ray photons that enter the telescope. In NICER specifically, the XRCs in the XTI consist of 24 concentric truncated cones, on which the X-ray photons complete a single bounce because, unlike previous instruments, XTI does not have to produce images and thus does not require a tight focus.

Having ended our digression, we return to the XTI's ability to measure with great precision the energy of the captured photons and their times of arrival on the detector. Knowing the exact energy of the X-ray photons means getting spectrometric values that can provide important information about the sources that emitted them. Knowing the exact arrival time for the X-ray photons, on the other hand, means being able to place each event with precision on the source's light curve, accumulating them over days and months of observation, provided they follow a regular, periodic progression, as happens with the targets chosen for NICER, which are pulsars without increases in mass from companion stars (a phenomenon that would contaminate their light curves, making analysis even more complicated). Now, how can NICER be so precise in observing ob-

Graphic representation of the NICER payload aboard the International Space Station. [NASA]



jects the size of a city, hundreds of light years away, that rotate on their axes hundreds of times per second? It can because its equipment can fix the events in time with a precision better than 300 nanoseconds, and because it knows its orbital position with a precision of ±5 metres. Of course, the proper motions of the pulsars themselves must be noted with precision, otherwise the results would be flawed. Something is still missing in explaining how NICER can solve our problem of having scant knowledge about the masses and diameters of neutron stars. These stars not only have a fearsome gravitational force, they also have a powerful magnetic field (at least 100 million times more than the Earth's) generated by their incredible rotation speed. The matter that is caught in the lines of force of that magnetic field is instantly accelerated to relativistic speeds and violently hits the pulsar's ultra-flat surface, near its magnetic poles. At the impact points, two spots are generated that are so hot that they emit X-rays, and these are the X-ray photons that NICER collects and measures.

The magnetic poles are generally tilted out of alignment from the rotational axis and, statistically speaking, this last will only rarely be facing the Earth; it follows that the vast majority of pulsars show us the two surface sources of X-rays in rapid sequence, once every half rotation.

The signal coming from them is modulated according to the rotational motion, and it intensifies for the source in the hemisphere moving closer to the observer, and it weakens for the one moving away.

The scenario is almost complete at this point. All we need is the involvement of the principal actor (whom we already met), the extraordinary gravitational force of the pulsars, which, in addition to compacting matter nearly to the point at which black holes form, also has the power to heavily bend the space around those degenerate stars, forcing some radiation leaving the surface to follow a path that we perceive as curved. This has an important consequence: we can sense part of the radiation emitted in the hemisphere opposite the one facing Earth at a determined instant. Because there is a proportion between the surplus of visible surface and the pulsar's mass, if we use the two 'hot spots' as tracers we can figure out how much total surface is visible and thereby find the values of the mass and diameter with a maximum error of ±5%. Finally, since various theoretical models calculate the different states of the matter and a different internal structure in the pulsars depending on the mass/diameter ratio, it will be possible to learn which model is most realistic and use it to derive other properties of those exotic celestial objects. ■

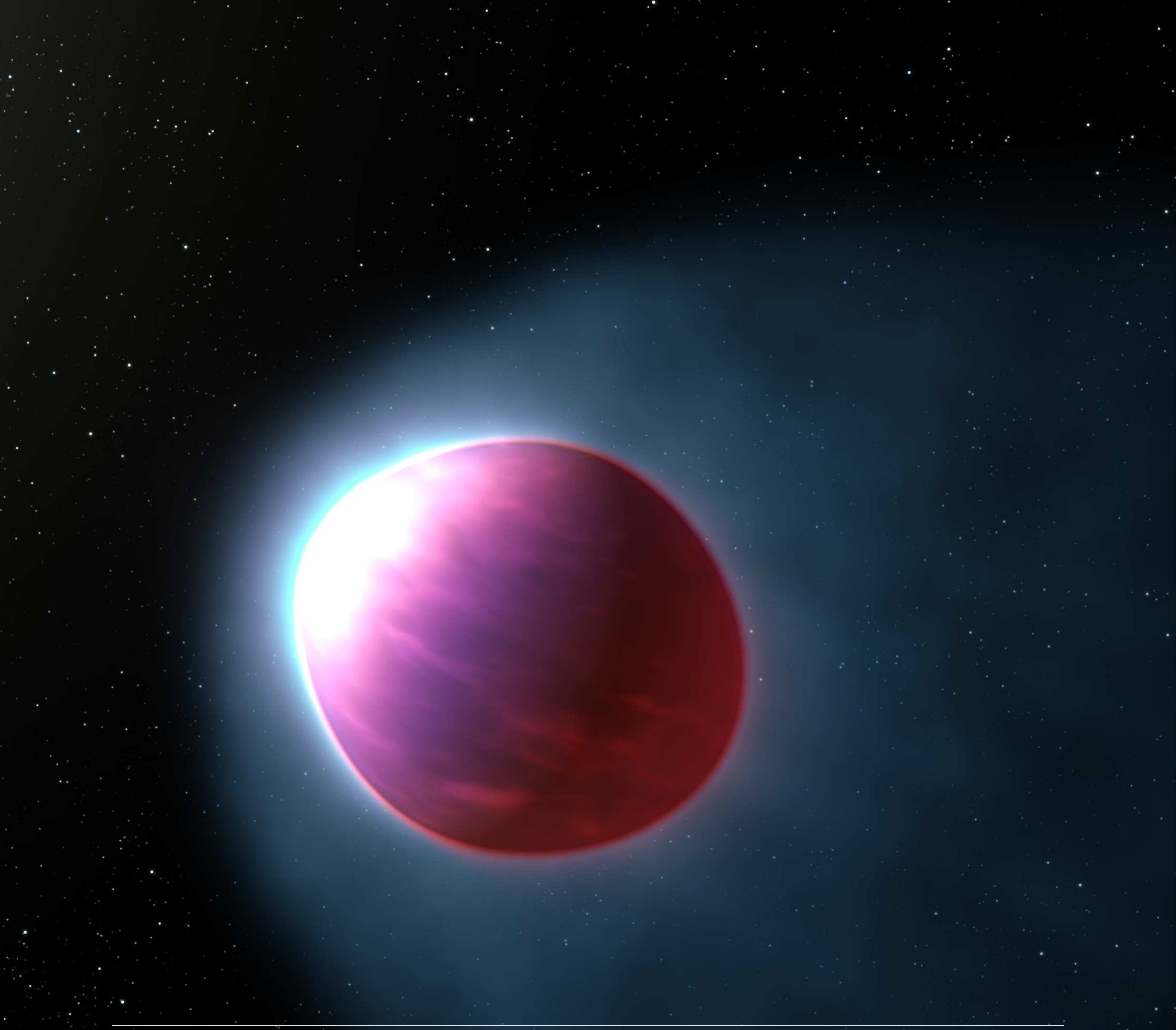
Exoplanet with glowing water atmosphere detected

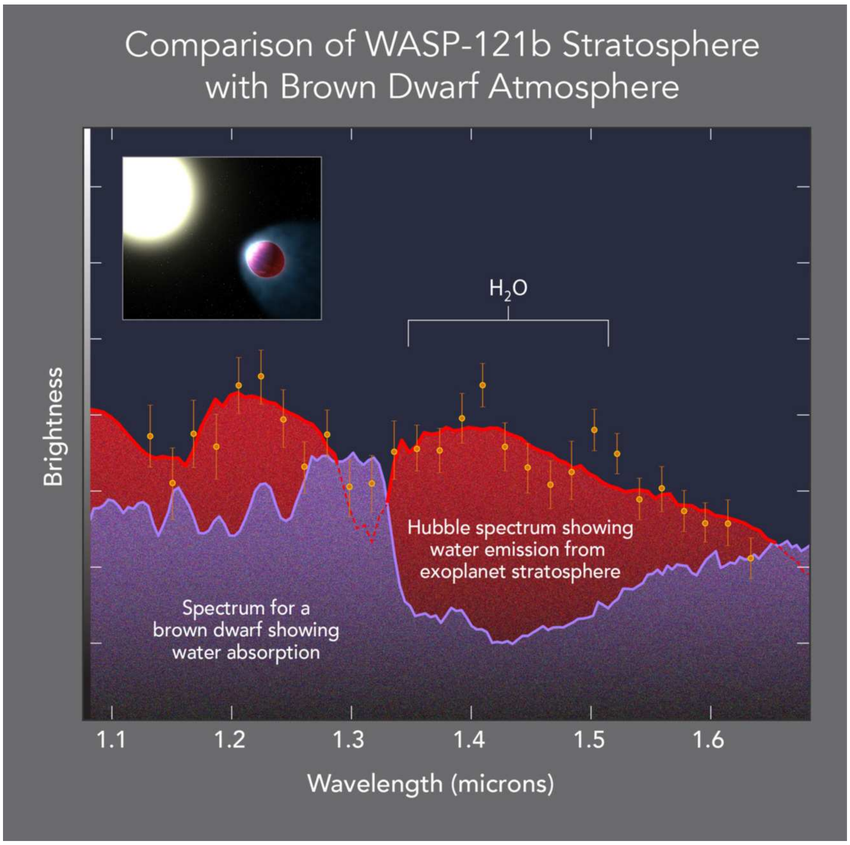
by NASA/ESA

Scientists have discovered the strongest evidence to date for a stratosphere on a planet outside our solar system, or exoplanet. A stratosphere is a layer of atmosphere in which temperature increases with higher altitudes.

"This result is exciting because it shows that a common trait of most of the atmospheres in our solar system — a warm stratosphere — also can be found in exoplanet atmospheres," said Mark Marley, study co-author based at NASA's Ames Research Center in California's Silicon Valley. "We can now compare processes in exoplanet atmospheres with the same processes that happen under different sets of conditions in our own solar system." Reporting in the journal *Nature*, scientists used data from NASA's Hubble Space Telescope to study WASP-121b, a type of exoplanet called a "hot Jupiter." Its mass is 1.2 times that of Jupiter, and its radius is about 1.9 times Jupiter's — making it puffier. But while Jupiter revolves around our Sun once every 12 years, WASP-121b has an orbital period of just 1.3 days. This exoplanet is so close to its star that if it got any closer, the star's gravity would start ripping it apart. It also means that the top of the planet's atmosphere is heated to a blazing 4,600 degrees Fahrenheit (2,500 degrees Celsius), hot enough to boil some metals. The WASP-121 system is estimated to be about 900 light-years from Earth — a long way, but close by galactic standards. Previous research found possible signs of a stratosphere on the exoplanet WASP-33b as well as some other hot Jupiters. The new study presents the best evidence yet because of the signature of hot water molecules that researchers observed for the first time. *"Theoretical models have suggested stratospheres may define a distinct class of ultra-hot planets, with important implications for their atmospheric physics and chemistry,"* said Tom Evans, lead author and research fellow at the University of Exeter, United Kingdom. *"Our observations support this picture."*

This is an artist's impression of the gas giant exoplanet WASP-121b. The bloated planet is so close to its star that the tidal pull of the star stretches it into an egg shape. The top of the planet's atmosphere is heated to a blazing 4,600 degrees Fahrenheit (2,500 degrees Celsius), hot enough to boil iron. This is the first planet outside our solar system where astronomers have found the strongest evidence yet for a stratosphere — a layer of atmosphere in which temperature increases with higher altitudes. The planet is about 900 light-years away. [Illustration: NASA, ESA, and G. Bacon (STScI) - Science: NASA, ESA, and T. Evans (University of Exeter)]





This diagram presents evidence for the existence of a stratosphere on a planet orbiting another star. As on Earth, the stratosphere increases in temperature with altitude. The water emissions from the Jupiter-sized planet's upper atmosphere show this. The results are in marked contrast to the spectrum of a failed star, a brown dwarf, which shows water absorption because the atmosphere is cooling with altitude increase. [NASA, ESA, and A. Feild (STScI)]

To study the stratosphere of WASP-121b, scientists analyzed how different molecules in the atmosphere react to particular wavelengths of light, using Hubble's capabilities for spectroscopy. Water vapor in the planet's atmosphere, for example, behaves in predictable ways in response to certain wavelengths of light, depending on the temperature of the water.

Starlight is able to penetrate deep into a planet's atmosphere, where it raises the temperature of the gas there. This gas then radiates its heat into space as infrared light. However, if there is cooler water vapor at the top of the atmosphere, the water molecules will prevent certain wavelengths of this light from escaping to space. But if the water molecules at the top of the atmosphere have a higher temperature, they will glow at the same wavelengths. *"The emission of light from water means the temperature is increasing with height,"* said Tiffany Kataria, study co-author based at NASA's Jet Propulsion Laboratory, Pasadena, California. *"We're excited to explore at what longitudes this behavior persists with upcoming Hubble observations."*

The phenomenon is similar to what happens with fireworks, which get their colors from chemicals emitting light. When metallic substances are heated and vaporized, their electrons move into higher energy states. Depending on the material, these electrons will emit light at specific wavelengths as they lose energy: sodium produces orange-yellow and strontium produces red in this process, for example. The water molecules in the atmosphere of WASP-121b similarly give off radiation as they lose energy, but in the form of infrared light, which the human eye is unable to detect.

In Earth's stratosphere, ozone gas traps ultraviolet radiation from the Sun, which raises the temperature of this layer of atmosphere. Other solar system bodies have stratospheres, too; methane is responsible for heating in the stratospheres of Jupiter and Saturn's moon Titan, for example. In solar system planets, the change in temperature within a stratosphere is typically around 100 degrees Fahrenheit (about 56 degrees Celsius). On WASP-121b, the temperature in the stratosphere rises by 1,000 degrees (560 degrees Celsius). Scientists do not yet know what chemicals are causing the temperature increase in WASP-121b's atmosphere. Vanadium oxide and titanium oxide are candidates, as they are commonly seen in brown dwarfs, "failed stars" that have some commonalities with exoplanets. Such compounds are expected to be present only on the hottest of hot Jupiters, as high temperatures are needed to keep them in a gaseous state. *"This super-hot exoplanet is going to be a benchmark for our atmospheric models, and it will be a great observational target moving into the Webb era,"* said Hannah Wakeford, study co-author who worked on this research while at NASA's Goddard Space Flight Center, Greenbelt, Maryland.

THE BEST IN HERITAGE *Projects of Influence*

Annual, global conference featuring award-winning museum, heritage and conservation projects

16th Edition

DUBROVNIK, CROATIA, 28 - 30 SEPTEMBER 2017

www.thebestinheritage.com

in partnership with EUROPA NOSTRA
with support of Creative Europe programme
& Endowment Fund of ICOM

EUROPA NOSTRA · Creative Europe · ICOM Fonds de dotation Endowment Fund · DU'M · EXPONATEC COLOGNE · MEYVAERT

dedicated to the memory of Kenneth Hudson OBE and Georges Henri Riviére

With
IMAGINES

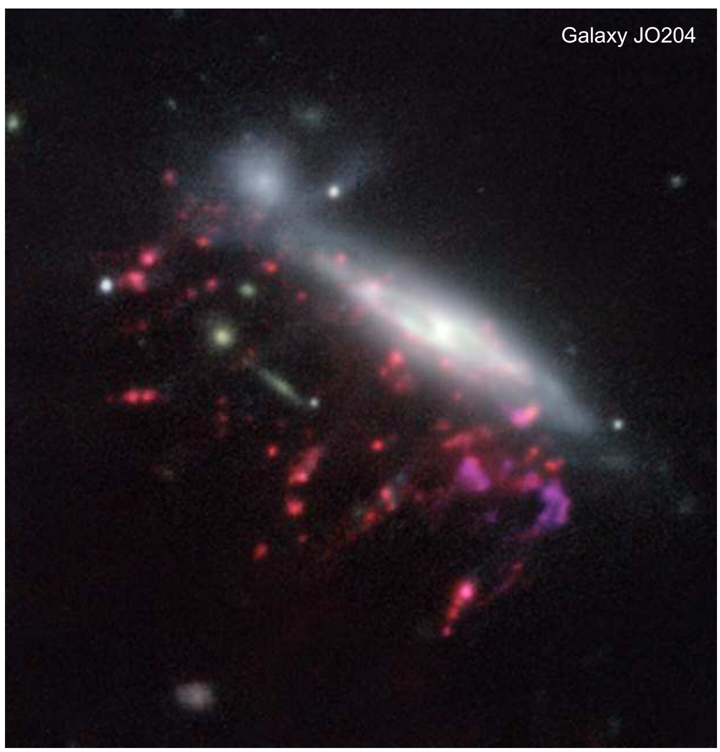
MUSE instrument discovers new way to fuel black holes

by ESO

An Italian-led team of astronomers used the MUSE (Multi-Unit Spectroscopic Explorer) instrument on the Very Large Telescope (VLT) at ESO's Paranal Observatory in Chile to study how gas can be stripped from galaxies.

They focused on extreme examples of jellyfish galaxies in near-by galaxy clusters, named after the remarkable long "tentacles" of material that extend for tens of thousands of light-years beyond their galactic discs. To date, just over 400 candidate jellyfish galaxies have been found.

The results were produced as part of the observational programme known as GASP (GAs Stripping Phenomena in galaxies with MUSE), which is an ESO Large Programme aimed at studying where, how and why gas can be removed from galaxies.



Observations of "Jellyfish galaxies" with ESO's Very Large Telescope have revealed a previously unknown way to fuel supermassive black holes. It seems the mechanism that produces the tentacles of gas and newborn stars that give these galaxies their nickname also makes it possible for the gas to reach the central regions of the galaxies, feeding the black hole that lurks in each of them and causing it to shine brilliantly. The pictures of these pages, from the MUSE instrument on ESO's Very Large Telescope in Chile, show clearly how material is streaming out of the galaxy in long tendrils. Red shows the glow from ionised hydrogen gas and the whiter regions are where most of the stars in the galaxy are located. [ESO/GASP collaboration]

GASP is obtaining deep, detailed MUSE data for 114 galaxies in various environments, specifically targeting jellyfish galaxies. Observations are currently in progress. The tentacles of jellyfish galaxies are produced in galaxy clusters by a process called ram pressure stripping.

Their mutual gravitational attraction causes galaxies to fall at high speed into galaxy clusters, where they encounter a hot, dense gas which acts like a powerful wind, forcing tails of gas out of the galaxy's disc and triggering starbursts within it.

Six out of the seven jellyfish galaxies in the study were found to host a supermassive black hole at the centre, feeding on the surrounding gas.

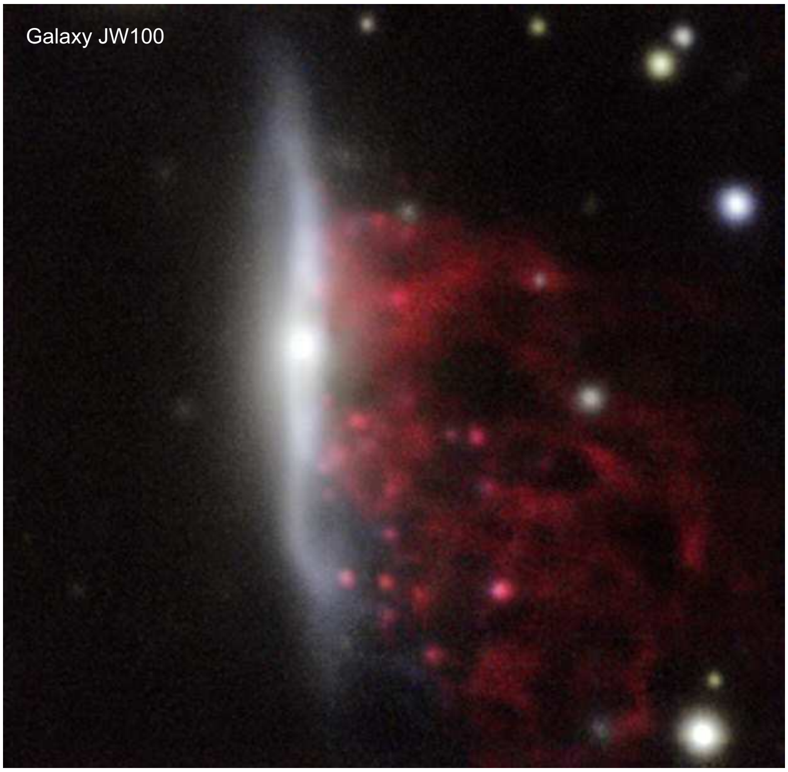
This fraction is unexpectedly high — among galaxies in general the fraction is less than one in ten. *"This strong link between ram pressure stripping and active black holes was not pre-*

dicted and has never been reported before," said team leader Bianca Poggianti from the INAF-Astronomical Observatory of Padova in Italy. *"It seems that the central black hole is being fed because some of the gas, rather than being removed, reaches the galaxy centre."*

The team also investigated the alternative explanation that the central AGN activity contributes to stripping gas from the galaxies, but considered it less likely.

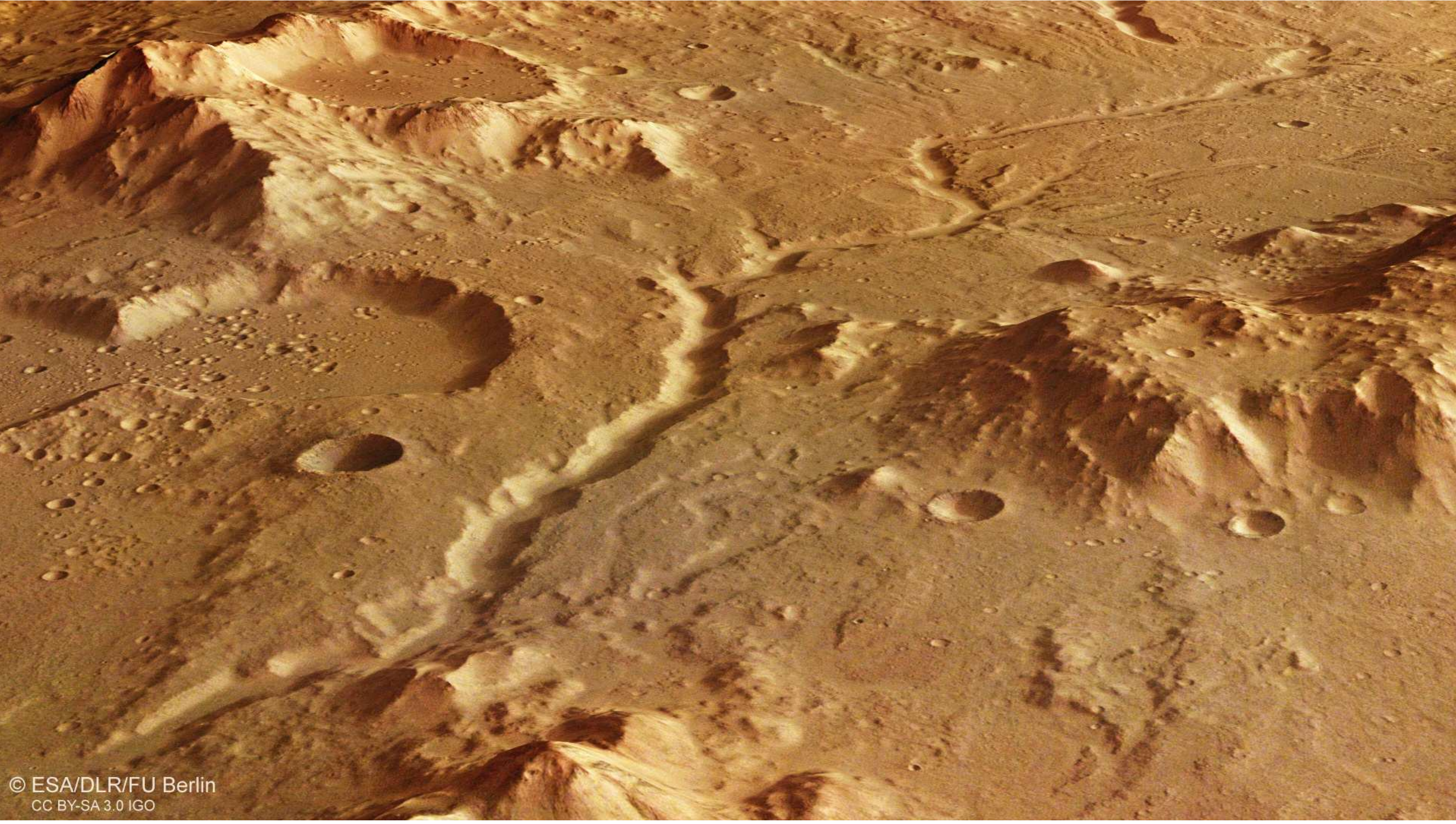
Inside the galaxy cluster, the jellyfish galaxies are located in a zone where the hot, dense gas of the intergalactic medium is particularly likely to create the galaxy's long tentacles, reducing the possibility that they are created by AGN activity. There is therefore stronger evidence that ram pressure triggers the AGN and not vice versa. A long-standing question is why only a small fraction of supermassive black holes at the centres of galaxies are active. Supermassive black holes are present in almost all galaxies, so why are only a few accreting matter and shining brightly? These results reveal a previously unknown mechanism by which the black holes can be fed.

Yara Jaffé, an ESO fellow who contributed to the paper explains the significance: *"These MUSE observations suggest a novel mechanism for gas to be funnelled towards the black hole's neighbourhood. This result is important because it provides a new piece in the puzzle of the poorly understood connections between supermassive black holes and their host galaxies."*



The current observations are part of a much more extensive study of many more jellyfish galaxies that is currently in progress.

"This survey, when completed, will reveal how many, and which, gas-rich galaxies entering clusters go through a period of increased activity at their cores," concludes Poggianti. *"A long-standing puzzle in astronomy has been to understand how galaxies form and change in our expanding and evolving Universe. Jellyfish galaxies are a key to understanding galaxy evolution as they are galaxies caught in the middle of a dramatic transformation."*



Tributes to wetter times on Mars

by ESA

A dried-out river valley with numerous tributaries is seen in this recent view of the Red Planet captured by ESA's Mars Express.

This section of the Libya Montes region, which sits on the equator at the boundary of the southern highlands and northern lowlands, was imaged on 21 February 2017 by the spacecraft's high-resolution stereo camera.

The Libya Montes highlands mountains, one of the oldest regions on Mars, were uplifted during the formation of the 1200 km-wide Isidis impact basin some 3.9 billion years ago, seen at the north of the context map.

The features seen across the broader region indicate both flowing rivers and standing bodies of water such as lakes or even seas that were present in the early history of Mars.

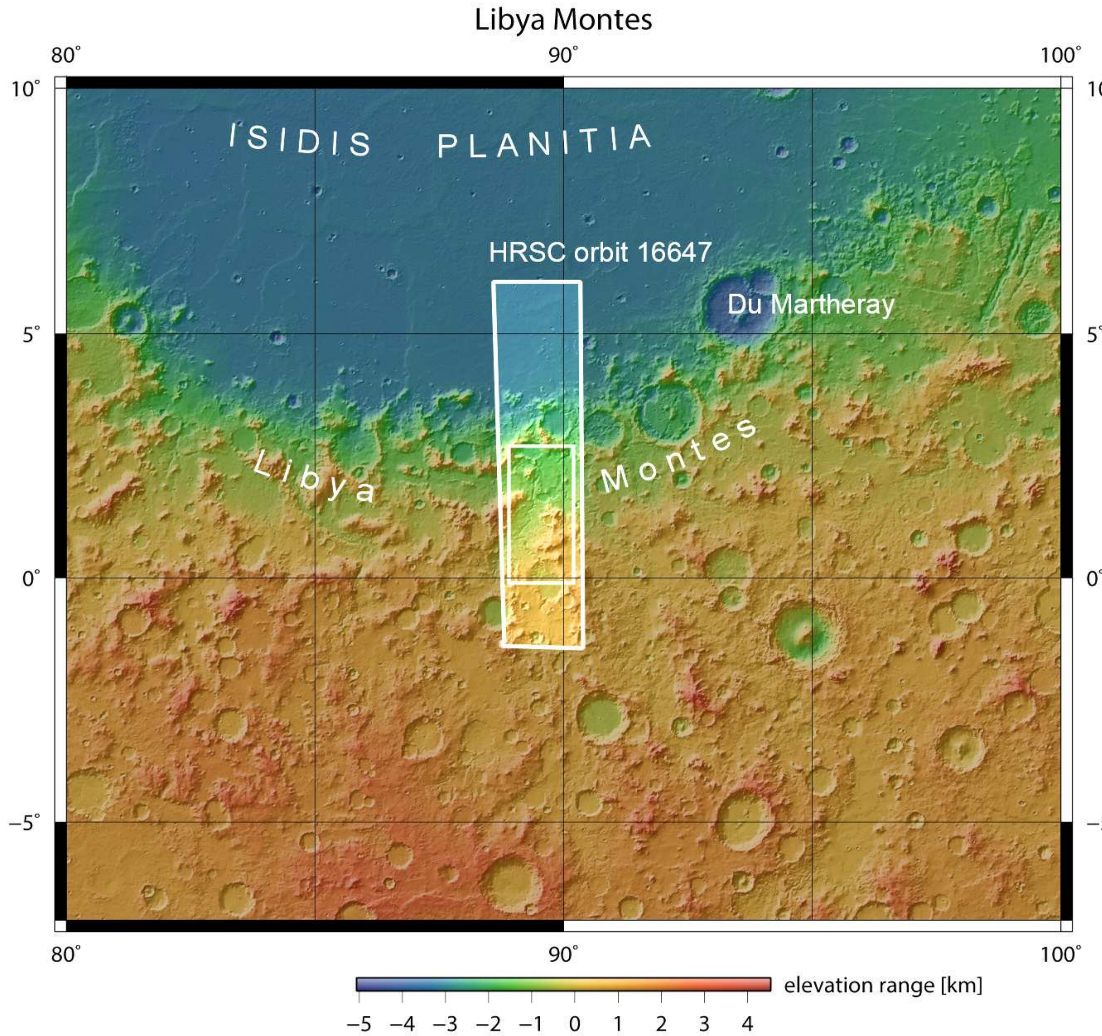
The prominent river channel that runs from south to north (left to right in the above image) is thought to have cut through the region around 3.6 billion years ago. It apparently originates from the impact crater in the south, breaching its crater wall and flowing towards the north, navigating the hummocky mountains of the local topography.

The valley is fed by numerous tributaries, pointing to extensive rainfall and surface runoff from higher to lower regions.

Groundwater seepage is also thought to have played a contribution in shaping the valley. A similar channel snakes its way across the bottom right of the scene.

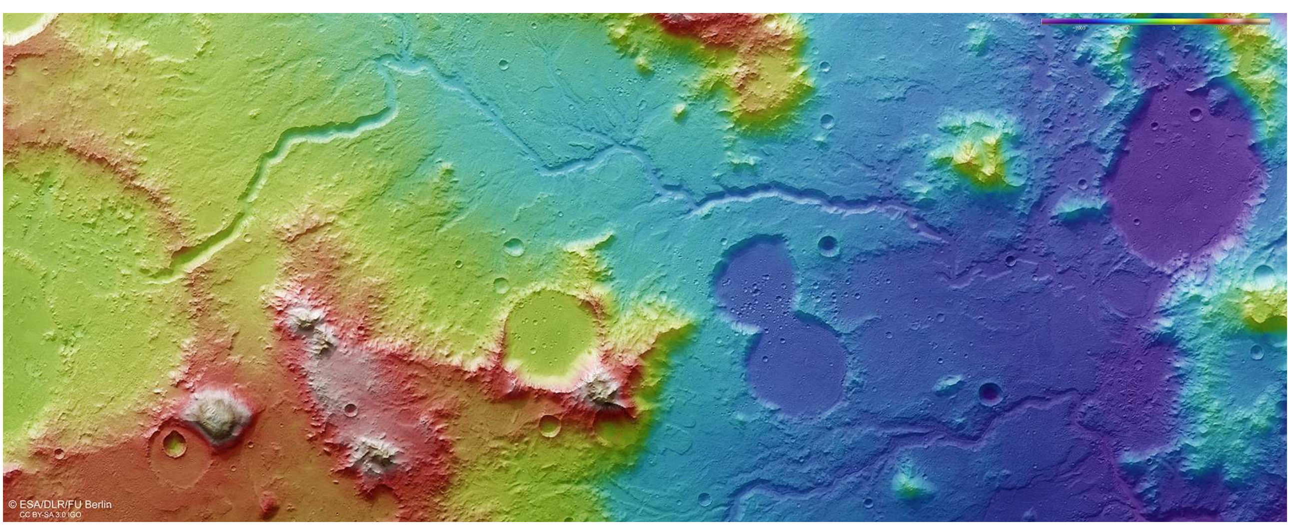
The mineralogy in the Libya Montes region is very diverse, as revealed by orbiting spacecraft. Aqueously formed and chemically altered minerals testify to past hydrothermal activity that may be linked to the formation of the Isidis impact basin. For example, the impact could have mobilised liquid water by melting subsurface

Perspective view looking along an ancient, dried out river channel in the Libya Montes region close to the equator on Mars. The valley snakes between hummocky mountain terrain and is fed by numerous tributaries arising from rainfall and surface runoff. To the left, part of a co-joined crater can be seen, its smooth floor pockmarked in smaller impact craters. The oblique perspective view was generated using data from the Mars Express high-resolution stereo camera stereo channels. This scene is part of the region imaged on 21 February 2017 during Mars Express orbit 16647. The main image is centred on 90°E / 1°N. In this orientation north is roughly to the bottom. [ESA/DLR/FU Berlin, CC BY-SA 3.0 IGO]



This map shows the location of Libya Montes in context of the surrounding region. The region outlined by the larger white box indicates the area imaged during Mars Express orbit 16647 on 21 February 2017. The small box in the centre highlights the focus of the associated image release. In this context image, north is up. [NASA MGS MOLA Science Team]

ice that subsequently interacted with the ancient, volcanic mountain rocks. Numerous craters in various states of degradation pockmark the entire scene, testament to the region's long history. Perhaps the most noticeable craters are the two situated side by side close to the centre of the scene (below), their breached crater walls connecting them and giving the appearance of a figure of eight shape. Another interesting crater lies to the left, nestled into the side of a hummocky mountain. Inevitably, its rim collapsed onto the valley floor beneath. Further left again, and a small crater has imprinted into the larger, wider crater, punching through to deeper layers below. The rich diversity of geologic features in this region – and in this image alone – showcases the dynamic environment the planet has witnessed through time, evolving from a warmer wetter climate that enabled liquid water to flow freely across the surface, to the arid world that we see today.

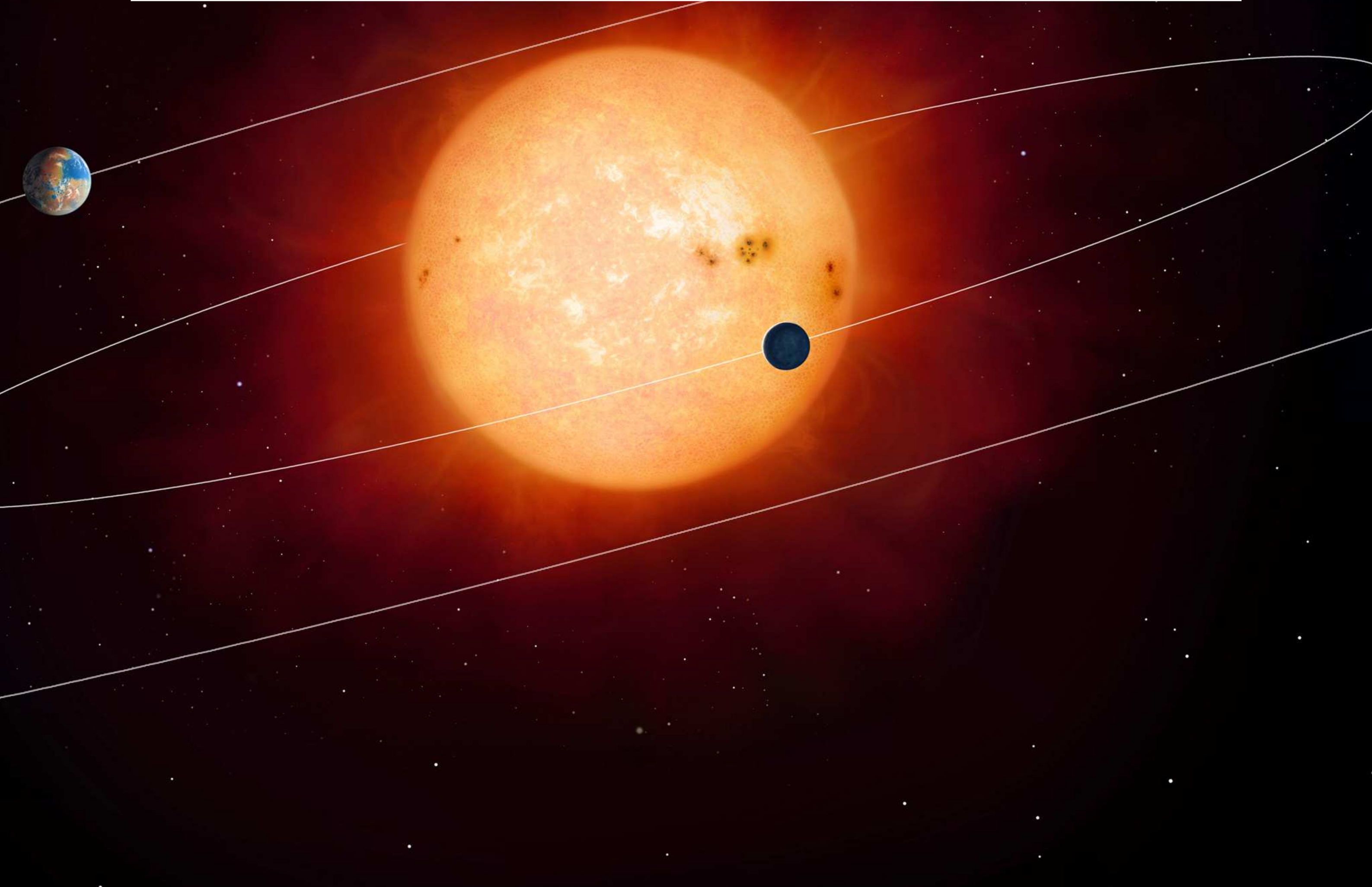


The colour-coded topographic view shows relative heights and depths of terrain in the Libya Montes region on Mars. As indicated in the key at top right, whites and reds represent the highest terrain, while blue/purple is the lowest. The color-coded topographic view is based on a digital terrain model of the region, from which the topography of the landscape can be derived. [ESA/DLR/FU Berlin, CC BY-SA 3.0 IGO]

The PLATO mission, a decisive step

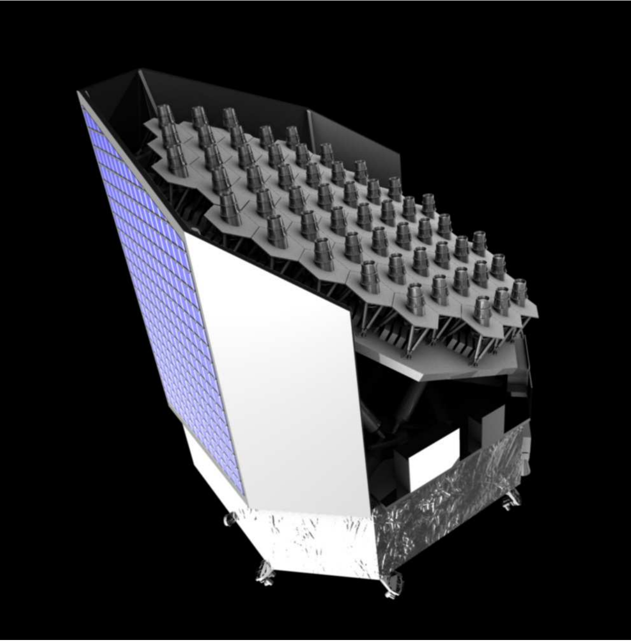
by Michele Ferrara

A representation of PLATO observing an exoplanet transiting the disc of a solar-type star. [Mark A. Garlick (space-art.co.uk) Science: Carole Haswell & Andrew Norton (OU)]

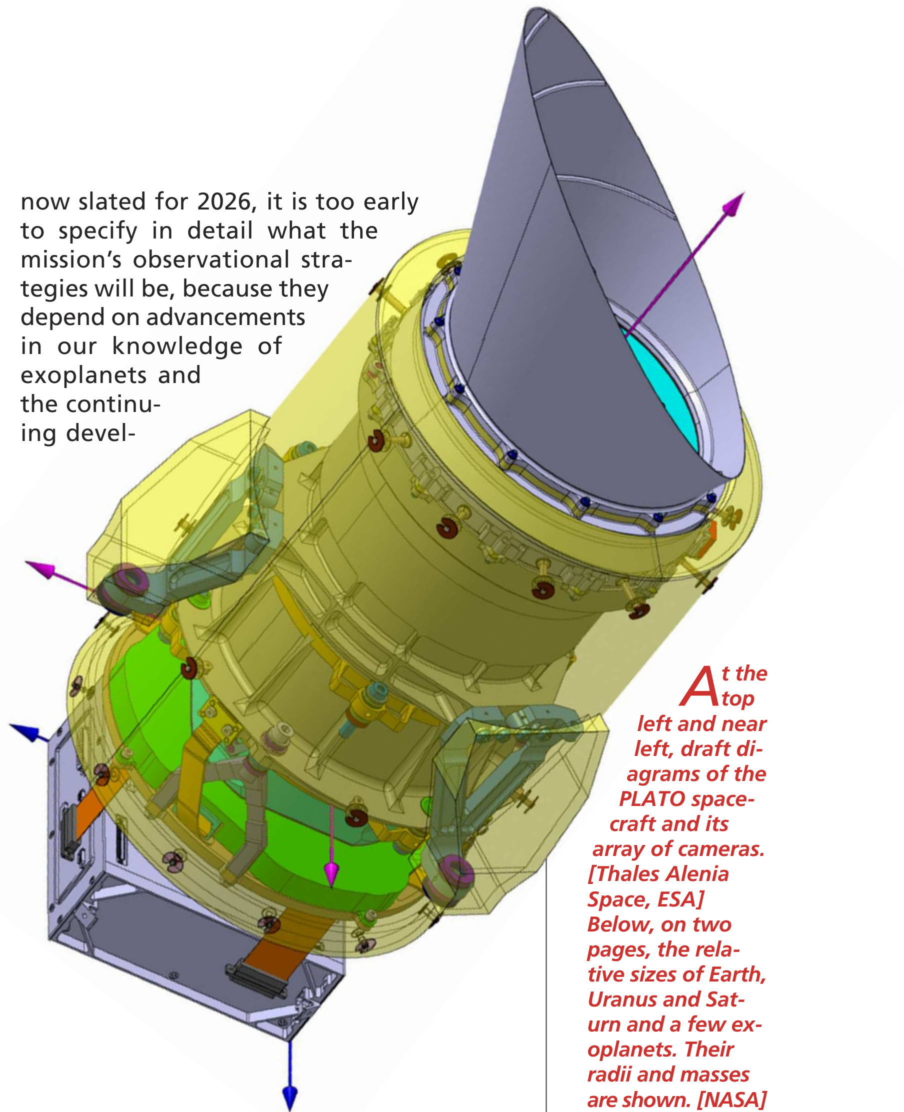


The Kepler space telescope brought us so close to discovering planets just like the Earth. Now the European Space Agency has started implementing an instrument that will harvest Kepler's legacy and help to provide a credible answer to the question most often asked by those who watch the night sky: "Is there life out there?"

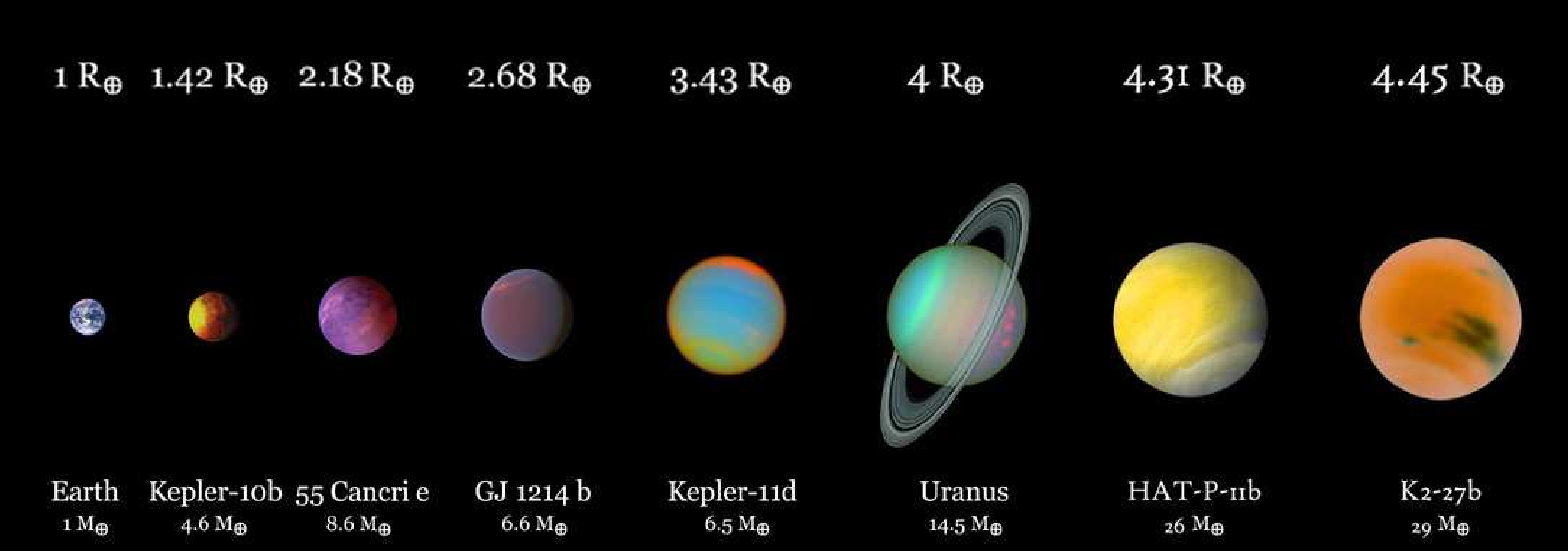
The PLATO mission will be done. The ESA's Science Programme Committee, which met in Madrid at the beginning of the summer, confirmed it. This news is very important, because PLATO, in in synergy with the ESO's Extremely Large Telescope (ELT) and NASA's James Webb Space Telescope (JWST), will be essential in discovering and verifying planets that are twins of the Earth and any life that may be present on them. PLATO is an acronym for PLAnetary Transits and Oscillations of stars, and its resemblance to the name of one of the greatest ancient Greek philosophers is no coincidence. The man named Plato sought a harmonious and uniform solution to the problem of the 'wandering stars' (the planets in our solar system); similarly, PLATO will help researchers bring order to the whole picture, which is currently rather confused, that describes the birth and evolution of planetary systems and the many variations we

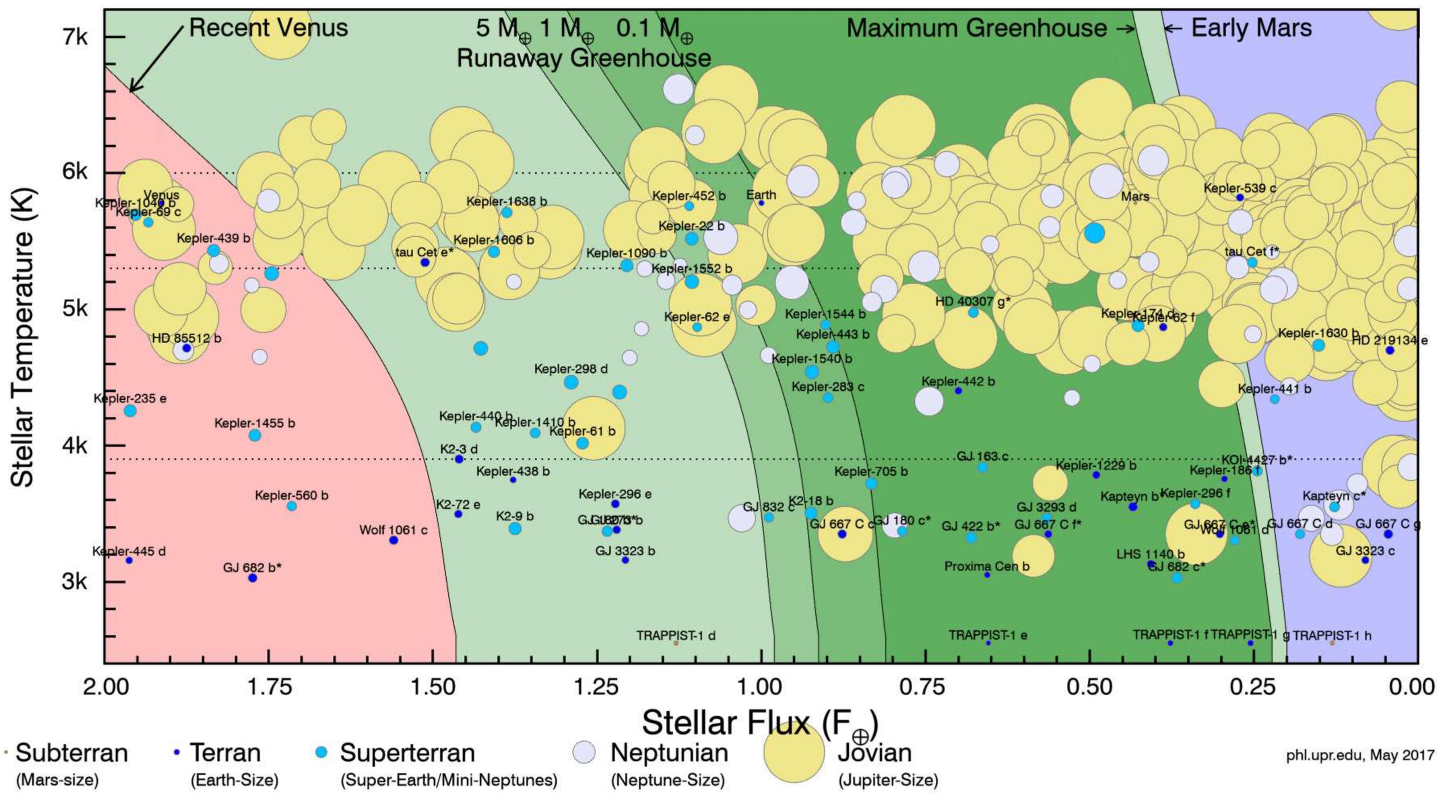


observe in them. The PLATO project has a ten-year history, having first been proposed in 2007 as a possible mission to undertake as part of the Cosmic Vision Programme 2015-2025 that the ESA presented in 2005 for the long-term planning of a cycle of space missions with diverse targets. After making it through the assessment (2009) and definition (2010) steps, the PLATO mission was selected in 2011 along with other candidates for a possible launch in 2024.
Three years later, PLATO became part of the Cosmic Vision Programme, and between 2015 and 2016 the ESA commissioned studies by Thales Alenia Space, OHB System AGV and Airbus DS to define the spacecraft's systems and subsystems. At last, on 20 June, PLATO was officially added to the ESA's scientific programme, which means moving from the design phase to the actual construction of the space vehicle and its instrumentation. Because launch is now slated for 2026, it is too early to specify in detail what the mission's observational strategies will be, because they depend on advancements in our knowledge of exoplanets and the continuing devel-



At the top left and near left, draft diagrams of the PLATO spacecraft and its array of cameras. [Thales Alenia Space, ESA] Below, on two pages, the relative sizes of Earth, Uranus and Saturn and a few exoplanets. Their radii and masses are shown. [NASA]

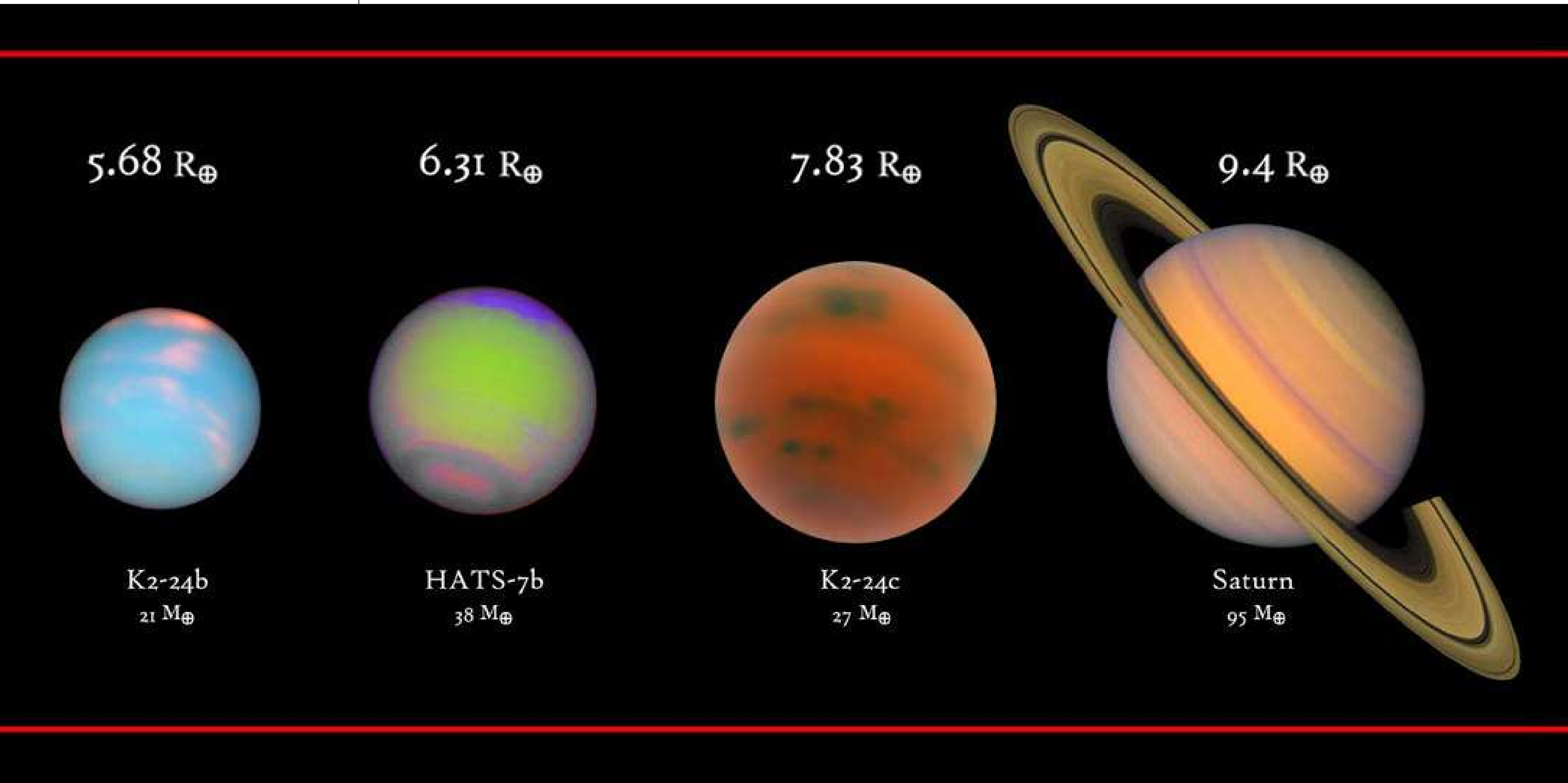


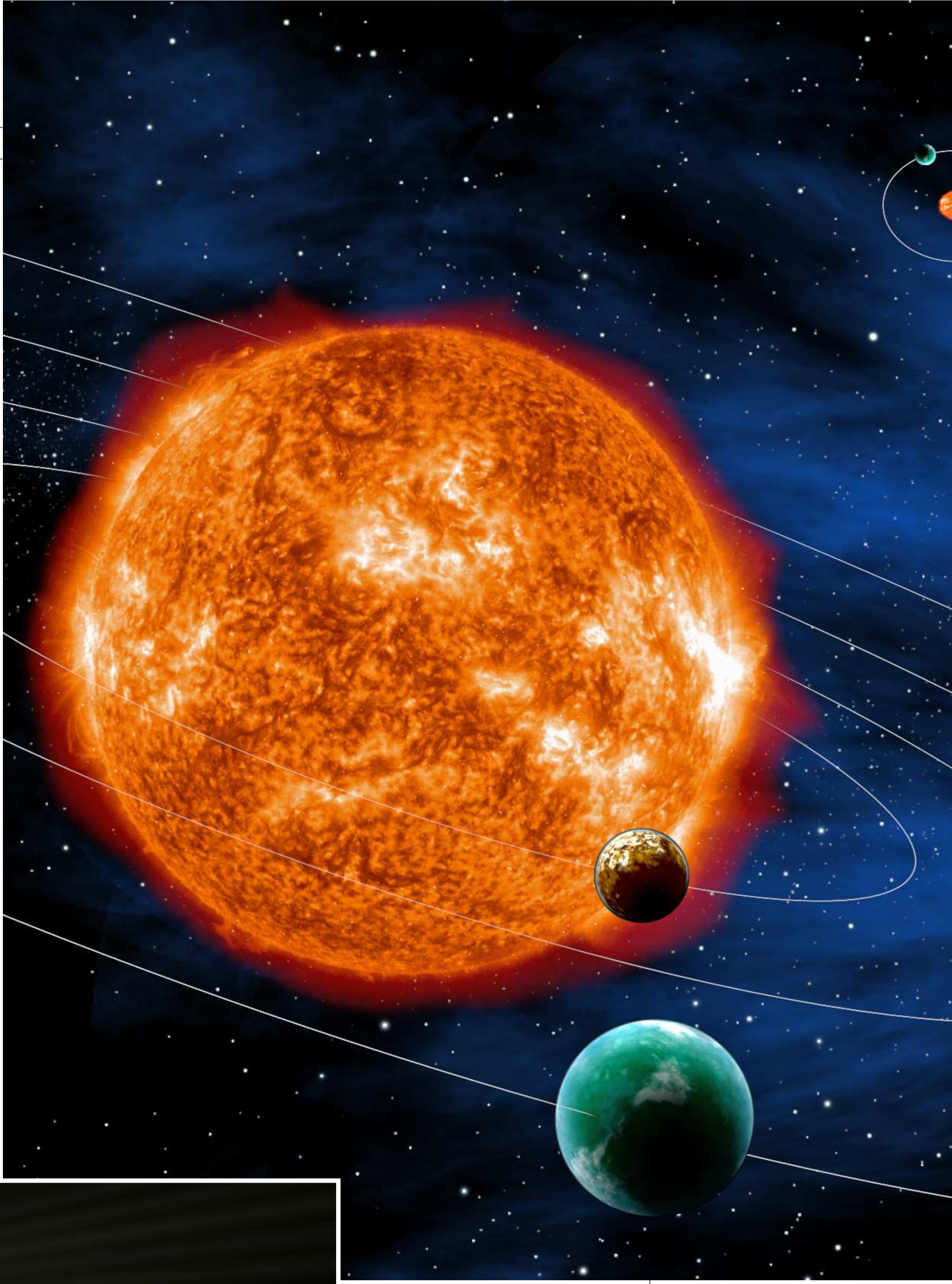


This graphic shows all planets near the habitable zone (darker green shade is the conservative habitable zone and the lighter green shade is the optimistic habitable zone). Only those planets less than 10 Earth masses or 2.5 Earth radii are labeled (= unconfirmed). [PHL @ UPR Arecibo]*

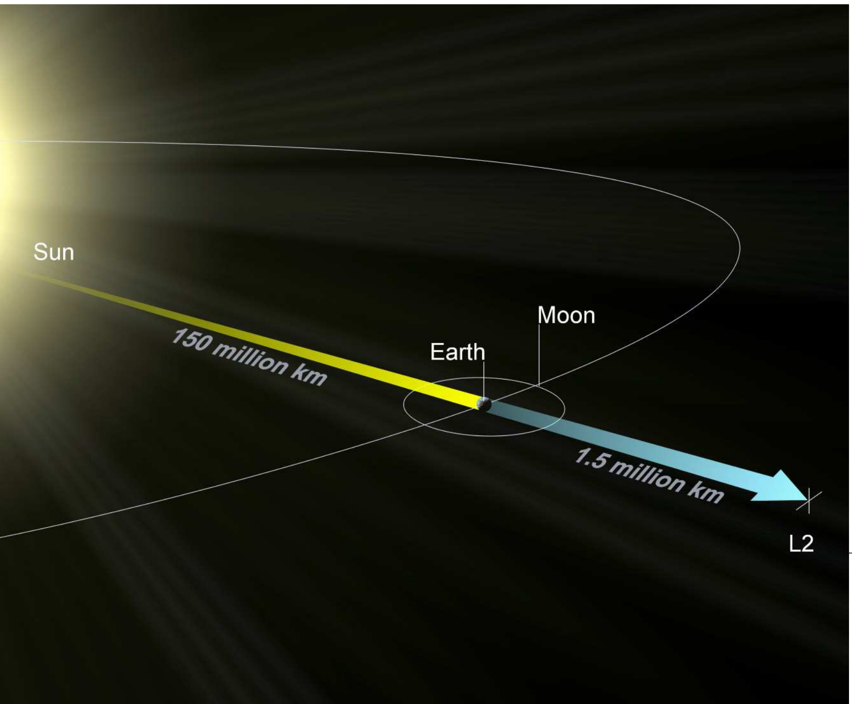
opment of the technologies that will equip the space observatory. Nevertheless, we can take an overview of the mission and the goals it wants to achieve. The medium-sized spacecraft and its load of scientific instruments will probably be launched with a Soyuz-Fregat rocket and put into a Lissajous orbit around Lagrangian point L2, about 1.5 million km from Earth, heading away from the Sun. The scientific instruments will consist of at least 26 six-lens white-light cameras, each having on its focal point 4 CCDs with 4150x4150 18-micron pixels. Each camera will cover 1100 square degrees of sky (the dimensions of the Aquarius constellation), but as they are arrayed in groups that are offset by about ten degrees, each pointing will allow it to capture about 2250 square degrees.

Twenty-four cameras in groups of 6 will continually monitor stars of a magnitude greater than 8 (up to magnitude 13, if not beyond) and the light they collect will be read every 25 seconds. The two remaining cameras will, instead, be devoted to more luminous stars with magnitudes between about 4 and 8 and will be scanned every 2.5 seconds. In the 4 years of its nominal mission (designed to last twice that), PLATO will cover between 10% and 50% of the sky and will constantly record the luminous intensity of probably between

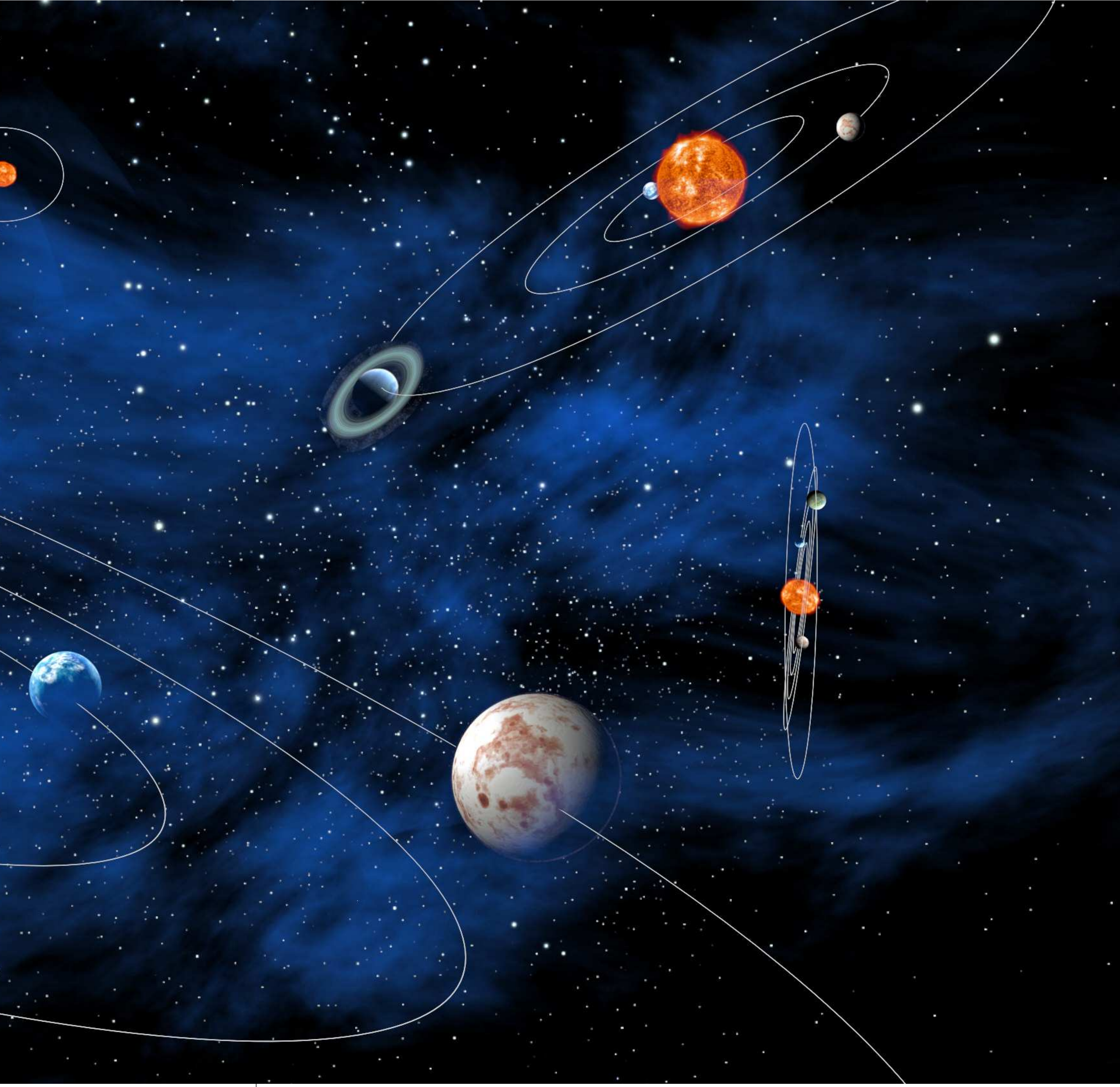




300,000 and 1 million stars (the counts are dependent on various observational strategies that might be adopted). As one may guess from the comprehensive name of this new space observatory, the countless photometric measurements it will perform during its mission will help discover planets transiting stellar discs and the oscillations that involve those stars, pulsations of a modest size that are displayed in the outermost layers.
PLATO's assignment will essentially be to demonstrate the existence of variations in luminosity and their periodicity, while it will be the task of the large ground- or space-based telescopes to confirm the existence of planets and oscillations, and to add as much information as possible. Unlike its predecessors CoRoT and Kepler, PLATO will study relatively bright and thus generally closer stars, enabling the determination of the orbital parameters and the main physical features of the planets and their stars. The accuracy of PLATO's photometric monitoring will allow the determination of the diameters of the transiting planets with just a 3% margin of error, and this will allow

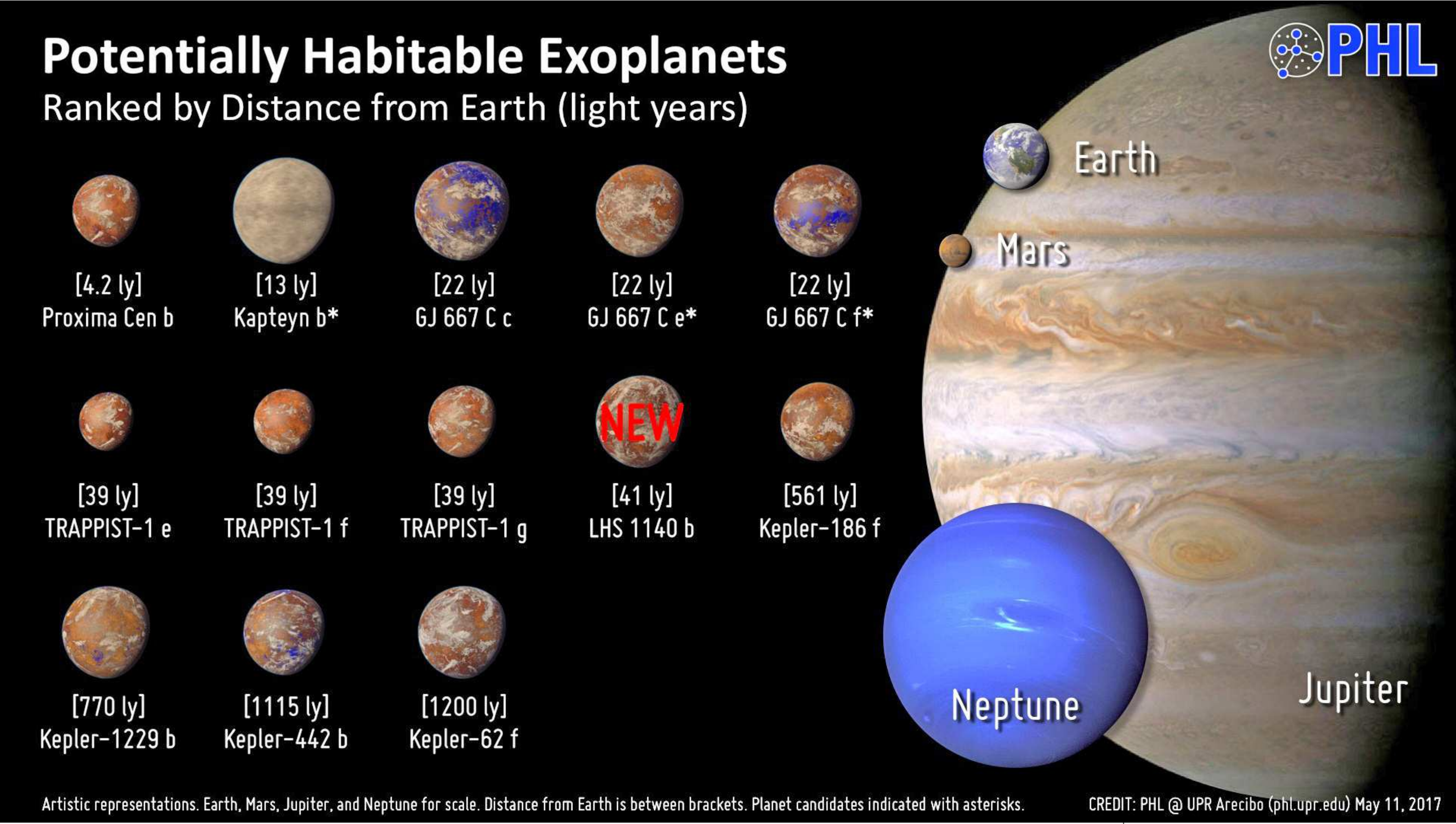


Above, the PLATO mission will assemble the first catalogue of confirmed and characterised planets with known mean densities, compositions, and evolutionary ages/ stages. [ESA, C. Carreau]. Left, a representation of the L2 point. [ESA]



the calculation of the planetary masses (using the radial velocity method) with a maximum error of 10%. To determine the precise mass of a planet, however, it is necessary to know equally precisely what the mass of its star is. Then, if we also know the star's diameter and age, we can have an idea of the system's evolutionary stage. And this is where the measurements of stellar oscillations come into play. PLATO will perceive them as very weak periodic variations in luminosity, characterised by a short duration (the 5-minute oscillation of the Sun, for example, is well known).

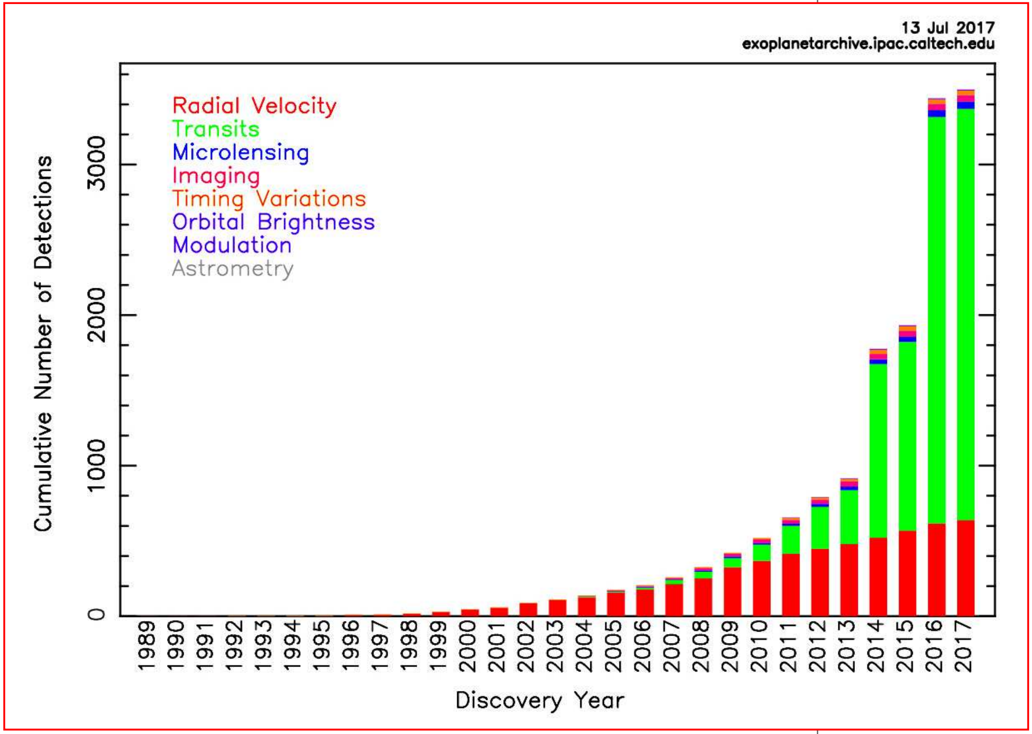
Using the mathematical tools available in asteroseismology, based on the properties of the oscillations PLATO measures researchers will be able to determine the internal structure of the observed stars, the movements of their outermost surface layers, and thereby to reach sufficiently reliable values (error lower than 10%) of their age, mass and diameter. The more precisely these values can be calculated, the easier it

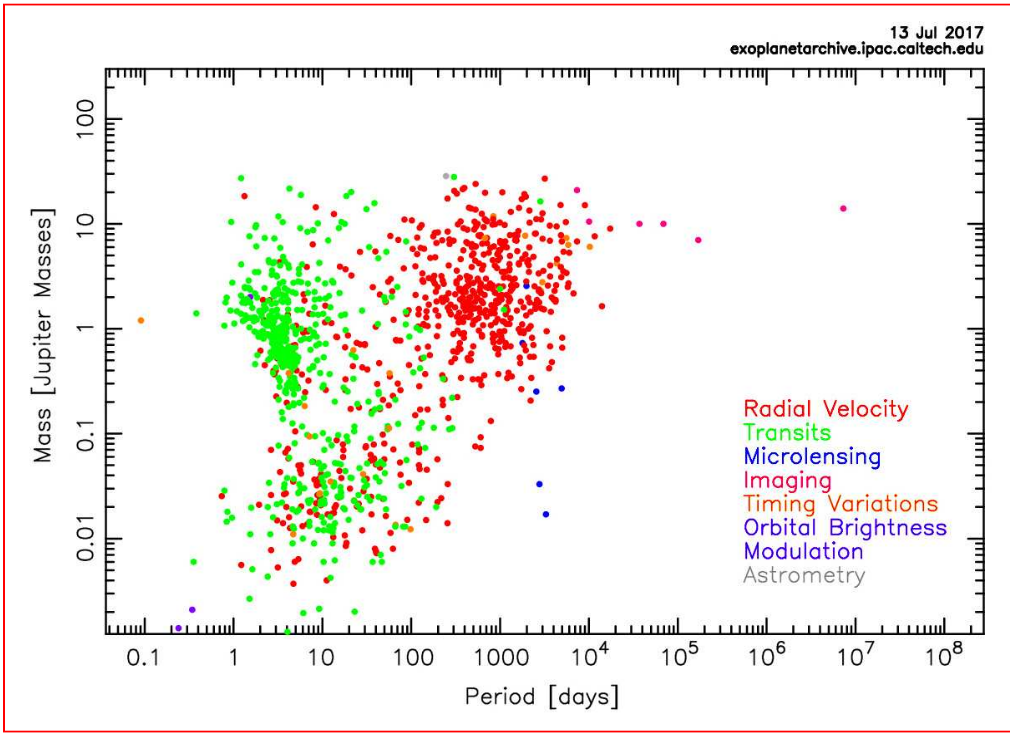


will be to classify the planets according to their physical properties. The roughly 3500 extrasolar planets confirmed to date have shown that, lacking accurate knowledge of their structure and that of their stars, it is often difficult to distinguish between an Earth, a super-Earth and a mini-Neptune. As we do not have examples of the latter two planetary classes in our solar system (which are rather prevalent in our Galaxy, however), we do not know the degree to which they may appear similar to each other at large distances, nor even if there are obvious borders between the classes, or if one class blends into another so that there are 'hybrid' planets.

As one may guess, a planet's classification, then, is made even more complex by the possible presence of an atmosphere, whose basic properties (size, density and composition) cannot be derived from transit photometry. In spite of all these difficulties, the precision of PLATO's measurements and the follow-up observations with large telescopes will allow us fairly reliably to classify tens of thousands of planets and, knowing the age of the systems they belong to, to understand how each planetary

Above, the potentially habitable planets closest to Earth. [PHL @ UPR Arecibo] Below, the increase in the number of discovered exoplanets. [Caltech]





Mass-period distribution of the exoplanets discovered to date with all the techniques available to astronomers. [Caltech]

class evolves over time as a function of stellar properties. The proper classification of a planet cannot be considered separately from the context in which it was formed and the time elapsed since its formation. That planets evolve dynamically and physically is a given: in the early stages of the formation of a planetary system, orbits change, sometimes noticeably; as millions and billions of years go by, Earth-sized planets lose their primordial atmosphere of hydrogen and replace it with one more conducive to life (as we know it); the atmospheres of smaller, rocky planets gradually dissolve in the flow of stellar radiation; finally, the gas giants cool and contract. In short, PLATO will play a key role in the proper interpretation of the structures of planetary systems, and we will finally know whether or not our solar system is similar to many others. Obviously, the most eagerly awaited discoveries will be those related to Earth-sized planets orbiting around a solar-type star within the habitable zone (where water can exist in liquid form). Although PLATO's targets will probably include red dwarfs and stars larger than the Sun, a number of recent studies have raised serious questions about the habitability of planets that orbit stars that are significantly different from the Sun. Researchers' attention will therefore likely be focussed on star-planet twins of the Sun-Earth system. Of the 3500 extrasolar planets confirmed to date (another 1000 are being verified), about 1% are of sizes similar to that of Earth and orbit within the habitable zone of their stars. If this percentage is representative of the totality of existing planets, we can expect PLATO to discover a few hundred planets potentially similar to Earth. Once the most promising targets have been selected, scientists will try to observe them at a distance from the stellar disc, and their atmospheres will be spectroscopically examined by JWST, ELT and the most powerful telescopes currently available to astronomers. Then we will know whether our galaxy contains habitable planets within relatively short distances from us and whether they already host life. ■

MASCARA sees first light at La Silla Observatory

by ESO

In June 2016, ESO reached an agreement with Leiden University to site a station of MASCARA at ESO's La Silla Observatory in Chile, taking advantage of the excellent observing conditions of the southern hemisphere skies. This station is now made its first successful test observations. The MASCARA station in Chile is the second to begin operations; the first station is in the northern hemisphere on the Roque de los Muchachos Observatory, on the island of La Palma in the Canary Islands. Each station contains a bat-

tery of cameras in a temperature-controlled enclosure which will monitor almost the entire sky visible from its location. MASCARA can monitor stars down to about magnitude 8.4 — roughly ten times fainter than can be seen with the naked eye on a clear dark night. Due to its design, MASCARA is less sensitive to weather condition than other observing instruments, and so observations may be made even when the sky is partially cloudy, thus extending observation times. *"Stations are needed in both the northern and southern hemisphere to obtain all-sky coverage,"* says Ignas Snellen, of Leiden University and the MASCARA project lead. *"With the second station at La Silla now in place, we can monitor almost all the brighter stars over the entire sky."*

Built by Leiden University in the Netherlands, MASCARA is a planet-hunting instrument. Its very compact and low-cost design appears unassuming, but is innovative, flexible and highly reliable. Consisting of five digital cameras with off-the-shelf components, this small planet-

The MASCARA (Multi-site All-Sky CAmeRA) station at ESO's La Silla Observatory in Chile achieved first light in July 2017. This new facility will seek out transiting exoplanets as they pass in front of their bright parent stars and create a catalogue of targets for future exoplanet characterisation observations. This nighttime view shows MASCARA in the foreground and other telescopes at the La Silla Observatory in the background, stretching up to the ESO 3.6-metre telescope that appears on the horizon. [ESO/G. Otten and G. J. Talens] hunter takes repeated measurements of the brightnesses of thousands of stars and uses software to hunt for the slight dimming of a star's light as a planet crosses the face of the star. This exoplanet discovery method is called transit photometry. The planet's size and orbit can be directly determined through this method, and in very bright systems the planet's atmosphere can also be characterised by further observations with large telescopes such as ESO's Very Large Telescope. The main purpose of MASCARA is to find exoplanets around the brightest stars in the sky, currently not probed either by space or ground-based surveys. The target population for MASCARA consists mostly of "hot Jupiters" — large worlds that are physically similar to Jupiter but orbit very close to their parent star, resulting in high surface temperatures and orbital periods of only a few hours. Dozens of hot Jupiters have been discovered with the radial velocity exoplanet detection method, as they exert a noticeably gravitational influence on their host stars. *"Not much can yet be learned from the planets discovered via the radial velocity method, as they require significantly better direct imaging techniques to separate the light of these cool, old planets*

The MASCARA at ESO's La Silla Observatory. This picture shows the system during installation as the sun is setting. [ESO/G. Otten and G. J. Talens]

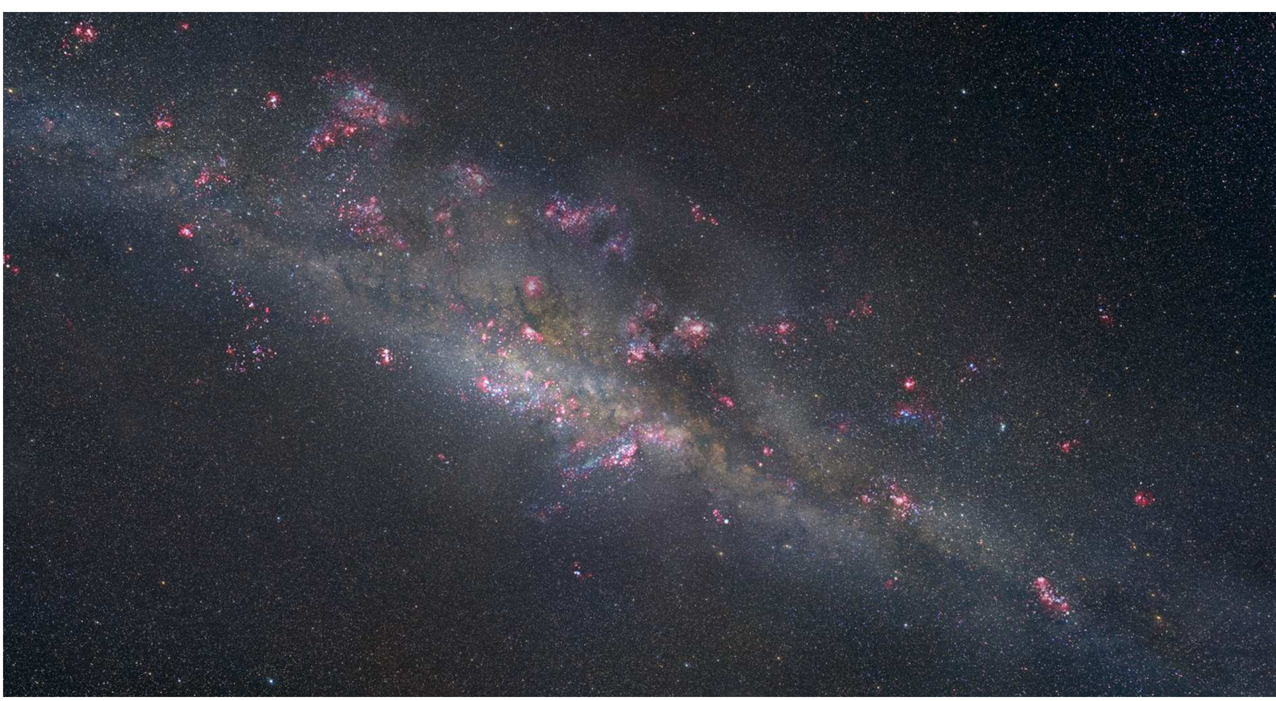
The five cameras the form the MASCARA system. Together the five wide-angle lenses allow MASCARA to image almost the entire visible sky in one go. [ESO/G. J. Talens]

from that of their host stars," comments Snellen. *"In contrast, planets that transit their host stars can readily be characterised."* MASCARA also has the potential to discover super-Earths and Neptune-sized planets. The project is expected to provide a catalogue of the brightest nearby targets for future exoplanet characterisation observations, particularly for detailed planetary atmosphere observations.

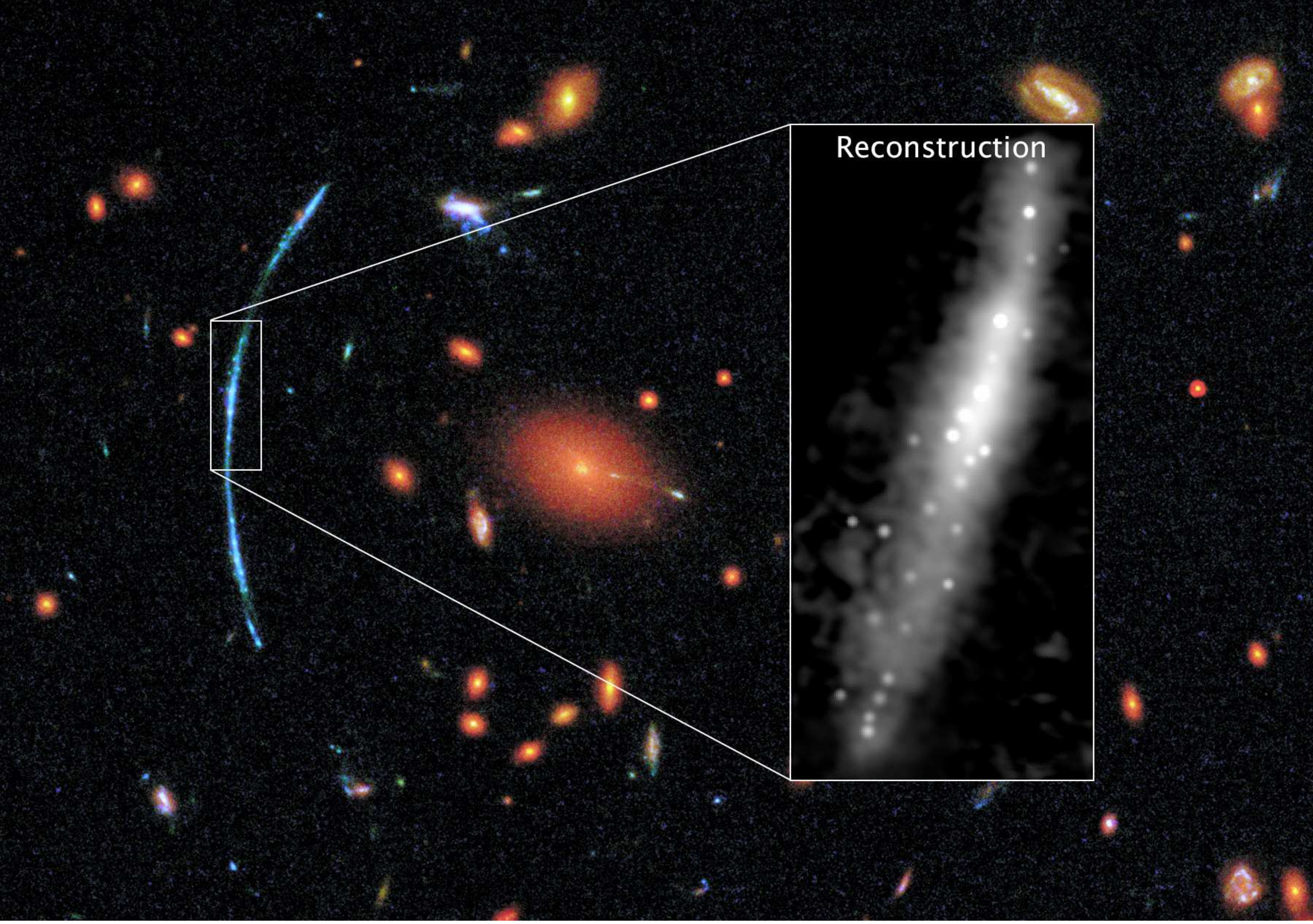
Hubble spots clumps of new stars in a distant galaxy

by NASA/ESA

When it comes to the distant universe, even the keen vision of NASA's Hubble Space Telescope can only go so far. Teasing out finer details requires clever thinking and a little help from a cosmic alignment with a gravitational lens. By applying a new computational analysis to a galaxy magnified by a gravitational lens, astronomers have obtained images 10 times sharper than what Hubble could achieve on its own. The results show an edge-on disk galaxy studded with brilliant patches of newly formed stars. *"When we saw the reconstructed image we said, 'Wow, it looks like fireworks are going off everywhere,'"* said astronomer Jane Rigby of NASA's Goddard Space Flight Center in Greenbelt, Maryland.



This artist's illustration portrays what the gravitationally lensed galaxy SDSS J1110+6459 might look like up close. A sea of young, blue stars is streaked with dark dust lanes and studded with bright pink patches that mark sites of star formation. The patches' signature glow comes from ionized hydrogen, like we see in the Orion Nebula in our own galaxy. According to new research, these distant star-formation regions are clumpy and span about 200 to 300 light-years. This contradicts earlier theories suggesting that such regions might be much larger, 3,000 light-years or more in size. [NASA, ESA, and Z. Levay (STScI)]



In this Hubble photograph of a distant galaxy cluster, a spotty blue arc stands out dramatically against a background of red galaxies. That arc is actually three separate images of the same background galaxy. The background galaxy has been gravitationally lensed, its light magnified and distorted by the intervening galaxy cluster. By using the magnifying power of this natural cosmic lens, astronomers have been able to study the background galaxy in intimate detail. Through sophisticated computer processing, they determined how the galaxy's image has been warped by gravity. The image at right shows how the galaxy would look to Hubble without distortions. It reveals a disk galaxy containing clumps of star formation that each span about 200 to 300 light-years. [NASA, ESA, and T. Johnson (University of Michigan)]

The galaxy in question is so far away that we see it as it appeared 11 billion years ago, only 2.7 billion years after the Big Bang. It is one of more than 70 strongly lensed galaxies studied by the Hubble Space Telescope, following up targets selected by the Sloan Giant Arcs Survey, which discovered hundreds of strongly lensed galaxies by searching Sloan Digital Sky Survey imaging data covering one-fourth of the sky.

The gravity of a giant cluster of galaxies between the target galaxy and Earth distorts the more distant galaxy's light, stretching it into an arc and also magnifying it almost 30 times. The team had to develop special computer code to remove the distortions caused by the gravitational lens, and reveal the disk galaxy as it would normally appear.

The resulting reconstructed image revealed two dozen clumps of newborn stars, each spanning about 200 to 300 light-years. This contradicted theories suggesting that star-forming regions in the distant, early universe were much larger, 3,000 light-years or more in size.

"There are star-forming knots as far down in size as we can see," said doctoral student Traci Johnson of the University of Michigan, lead author of two of the three papers describing the research.

Without the magnification boost of the gravitational lens, Johnson added, the disk galaxy would appear perfectly smooth and unremarkable to Hubble. This would give astronomers a very different picture of where stars are forming.

While Hubble highlighted new stars within the lensed galaxy, NASA's James Webb Space Telescope will uncover older, redder stars that formed even earlier in the galaxy's history. It will also peer through any obscuring dust within the galaxy.

"With the Webb Telescope, we'll be able to tell you what happened in this galaxy in the past, and what we missed with Hubble because of dust," said Rigby.

These findings appear in a paper published in *The Astrophysical Journal Letters*, and two additional papers published in *The Astrophysical Journal*.

Preparing for Mercury: BepiColombo stack completes testing

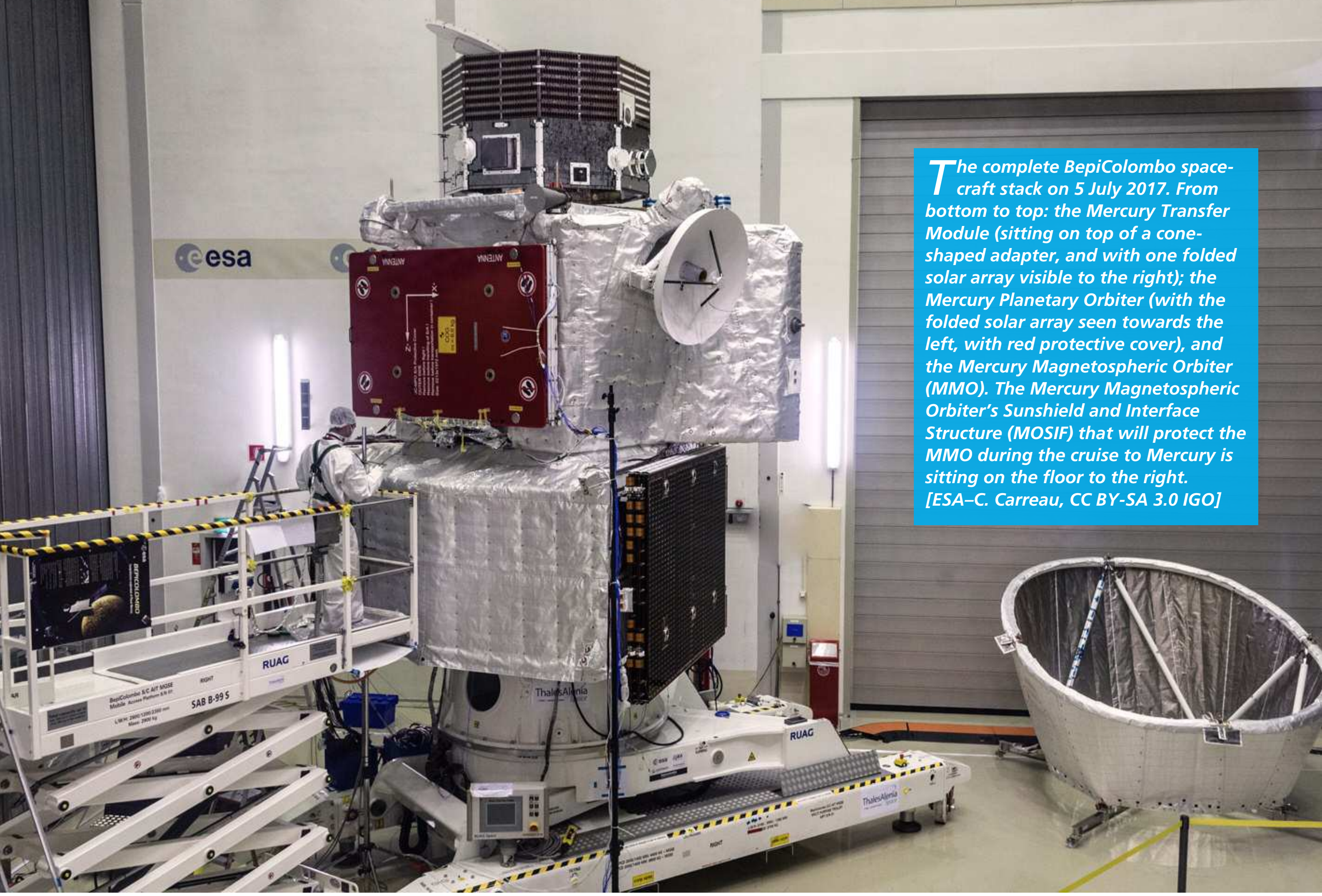
by ESA

ESA's Mercury spacecraft has passed its final test in launch configuration, the last time it will be stacked like this before being reassembled at the launch site next year.

BepiColombo's two orbiters, Japan's Mercury Magnetospheric Orbiter and ESA's Mercury Planetary Orbiter, will be carried together by the Mercury Transport Module. The carrier will use a combination of electric propulsion and multiple gravity-assists at Earth, Venus and Mercury to complete the 7.2 year journey to the Solar System's mysterious innermost planet. Once at Mercury, the orbiters will separate and move into their own orbits to make complementary measurements of Mercury's interior, surface, exosphere and magnetosphere. The information will tell us more about the origin and evolution of a planet close to its parent star, providing a better understanding of the overall evolution of our own Solar System.

To prepare for the harsh conditions close to the Sun, the spacecraft have undergone extensive testing both as separate units, and in the 6 m-high launch and cruise configuration. One set of tests carried out earlier this year at ESA's technical centre in the Netherlands focused

BepiColombo seen at ESA's test centre on 6 July 2017. ESA's Mercury spacecraft has passed its final test in launch configuration. To prepare for the harsh conditions close to the Sun, the spacecraft have undergone extensive testing both as separate units, and in the 6 m-high launch and cruise configuration. [ESA–Philippe Sebirot]

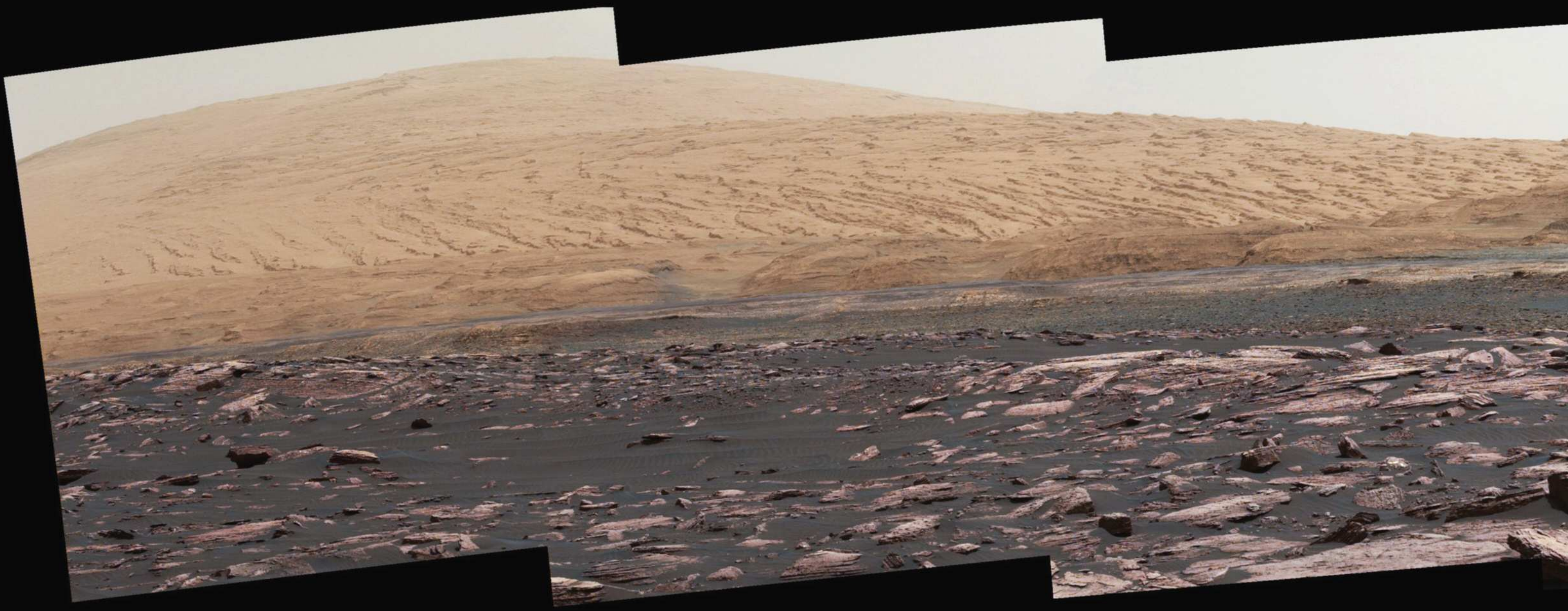


The complete BepiColombo spacecraft stack on 5 July 2017. From bottom to top: the Mercury Transfer Module (sitting on top of a cone-shaped adapter, and with one folded solar array visible to the right); the Mercury Planetary Orbiter (with the folded solar array seen towards the left, with red protective cover), and the Mercury Magnetospheric Orbiter (MMO). The Mercury Magnetospheric Orbiter's Sunshield and Interface Structure (MOSIF) that will protect the MMO during the cruise to Mercury is sitting on the floor to the right. [ESA–C. Carreau, CC BY-SA 3.0 IGO]

on deploying the solar wings, and the mechanisms that lock each panel in place. The 7.5 m-long array of the Mercury Planetary Orbiter and the two 12 m-long array of the Mercury Transport Module will be folded while inside the Ariane 5 rocket. In June, the full spacecraft stack was tested inside the acoustic chamber, where the walls are fitted with powerful speakers that reproduce the noise of launch. In July, tests mimicked the intense vibrations experienced by a satellite during launch. The complete stack was shaken at a range of frequencies, both in up-down and side-to-side motions. These were the final tests to be completed with BepiColombo in mechanical launch configuration, before it is reassembled again at the launch site. Subsequently the assembly was dismantled to prepare the transfer module for its last test in the thermal–vacuum chamber. This will check it will withstand the extremes of temperatures en route to Mercury. The final 'qualification and acceptance review' of the mission is foreseen for early March. Then BepiColombo will be flown to Europe's Spaceport in Kourou, French Guiana, in preparation for the October 2018 departure window. The date will be confirmed later this year.

"This vibrations test was the last opportunity to see the spacecraft in its stacked launch configuration before it leaves Europe. The next time will be when we are at the launch site already fueled," says Ulrich Reininghaus, ESA's BepiColombo Project Manager. "This is quite a milestone for the project team. We are looking forward to completing the final tests this year, and shipping to Kourou on schedule." ■

Animation visualising BepiColombo's 7.2 year journey to Mercury. This animation is based on a launch date of 5 October, marking the start of the launch window in October 2018. It illustrates the gravity assist flybys that the spacecraft will make at Earth, Venus and Mercury before arriving at Mercury in December 2025. [ESA - European Space Agency, CC BY-SA 3.0 IGO]

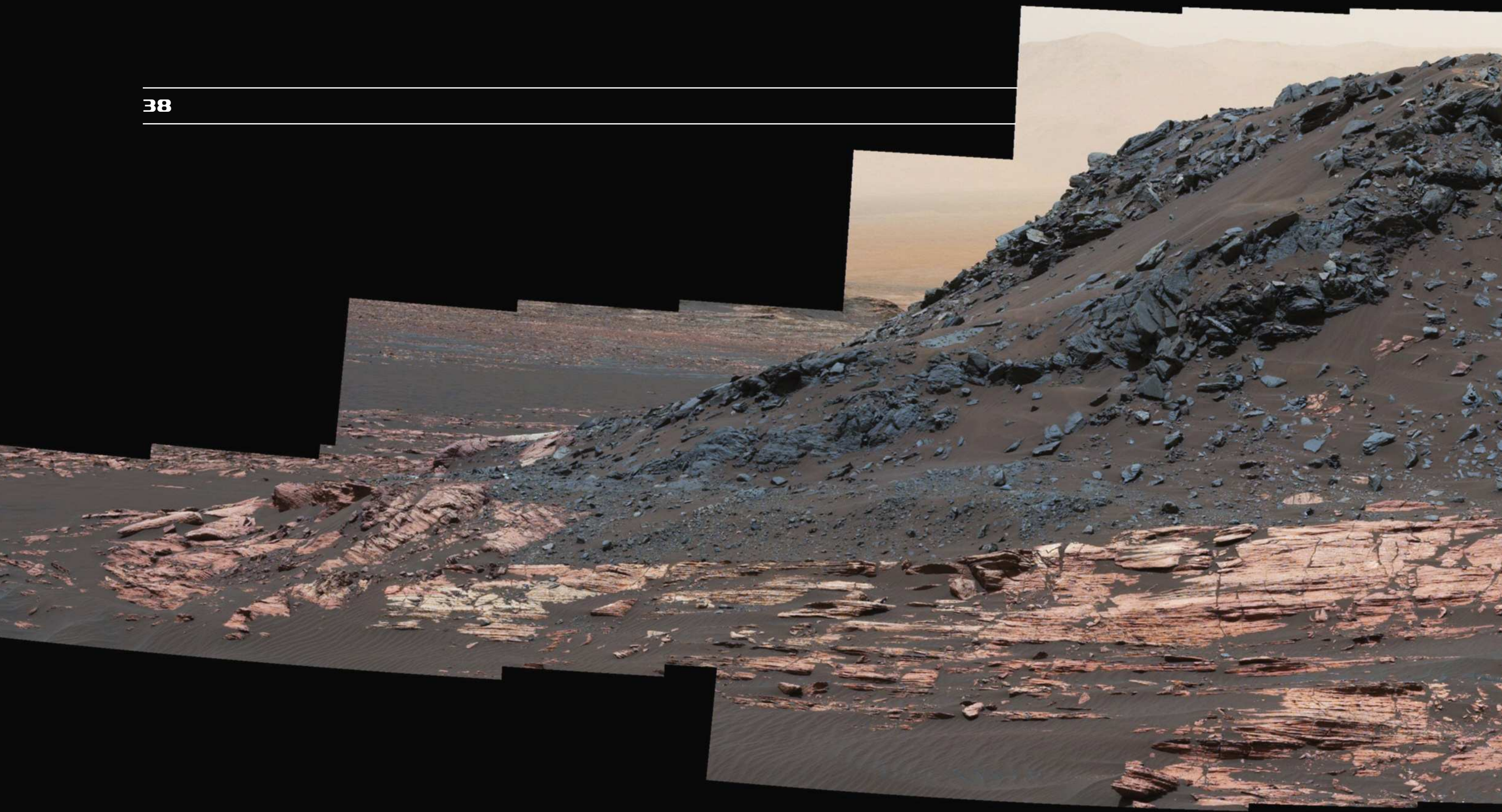


Five years of Curiosity on Mars

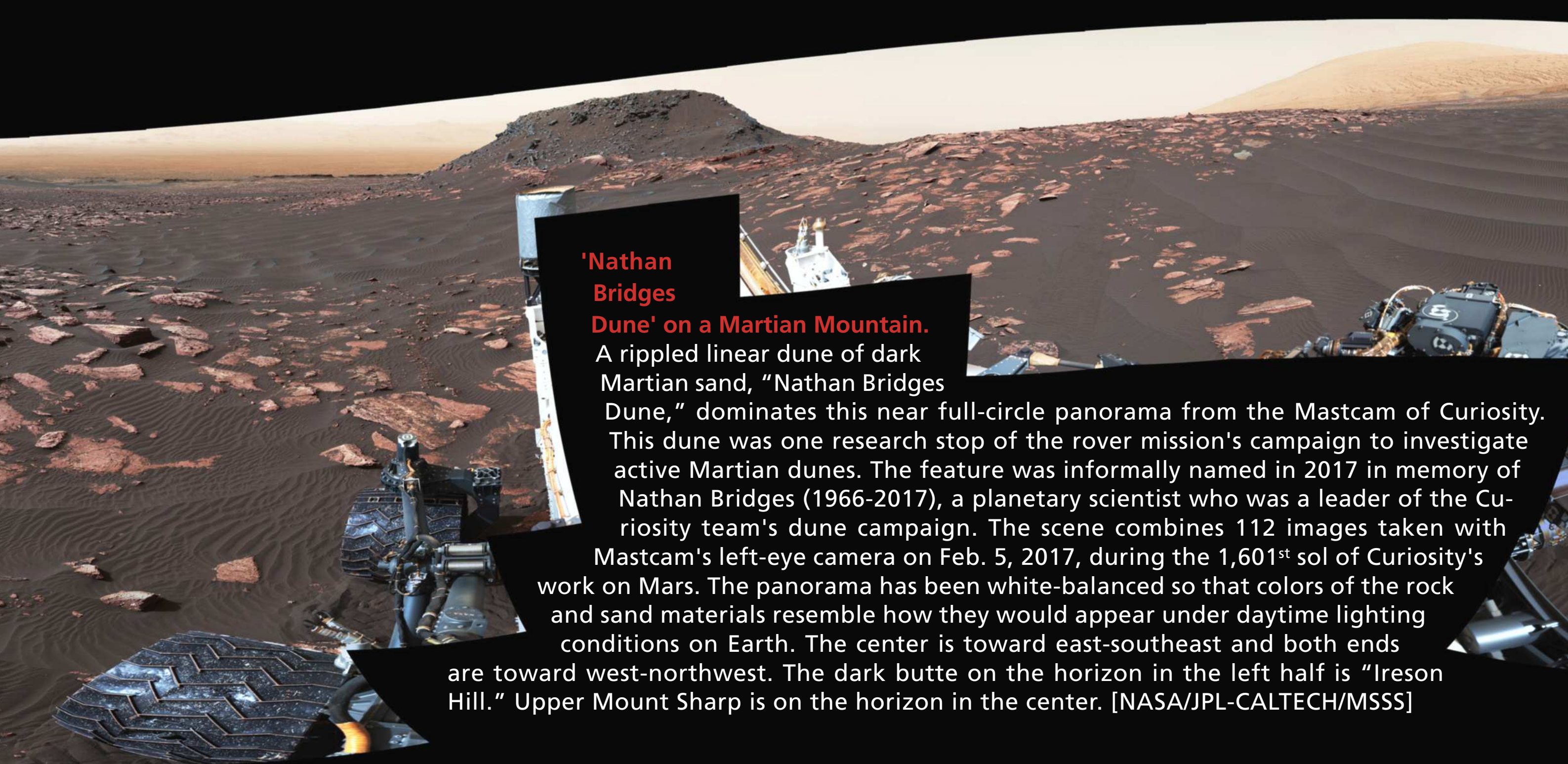
by NASA

Five years have passed since NASA's Curiosity rover landed near Mount Sharp on Mars. All along this period, Curiosity has driven over 10 miles, taking over 200,000 images. In this symbolic tribute to the mission, we introduce you some of the latest spectacular Martian landscapes created by merging and elaborating many different raw images.

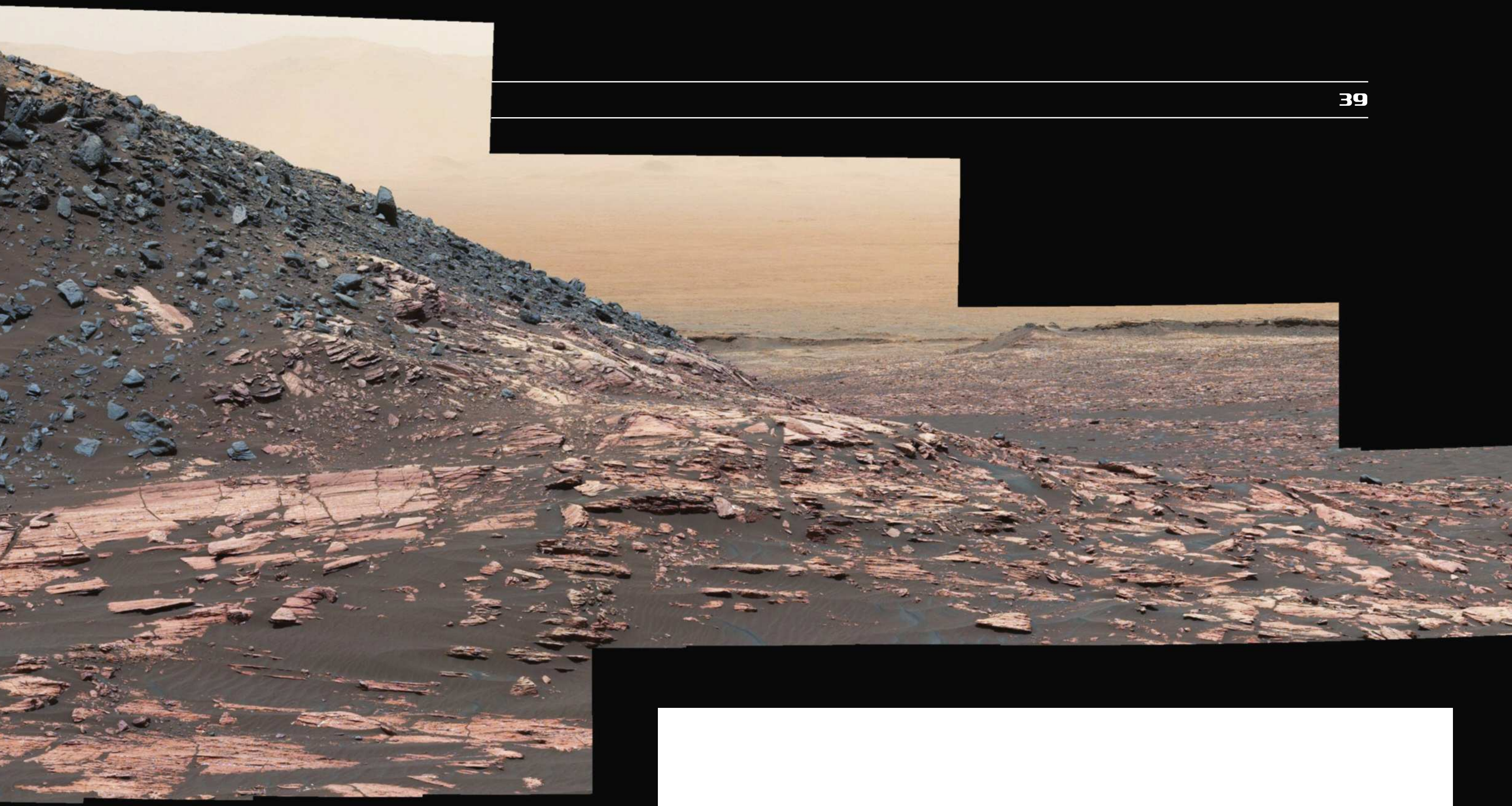
View toward 'Vera Rubin Ridge' on Mount Sharp, Mars.
This look ahead from NASA's Curiosity Mars rover includes four geological layers to be examined by the mission, and higher reaches of Mount Sharp beyond the planned study area. The redder rocks of the foreground are part of the Murray formation. Pale gray rocks in the middle distance of the right half of the image are in the Clay Unit. A band between those terrains is "Vera Rubin Ridge." Rounded brown knobs beyond the Clay Unit are in the Sulfate Unit, beyond which lie higher portions of the mountain.
The view combines six images taken with the rover's Mast Camera (Mastcam) on Jan. 24, 2017, during the 1,589th Martian day, or sol, of Curiosity's work on Mars, when the rover was still more than half a mile (about a kilometer) north of Vera Rubin Ridge. The panorama has been white-balanced so that the colors of the rock and sand materials resemble how they would appear under daytime lighting conditions on Earth. It spans from east-southeast on the left to south on the right. The ridge was informally named in early 2017 in memory of Vera Cooper Rubin (1928-2016), whose astronomical observations provided evidence for the existence of the universe's dark matter.
Below, two close-ups extracted from another mosaic of the same area and consisting of 112 single images.
[NASA/JPL-CALTECH/MSSS]



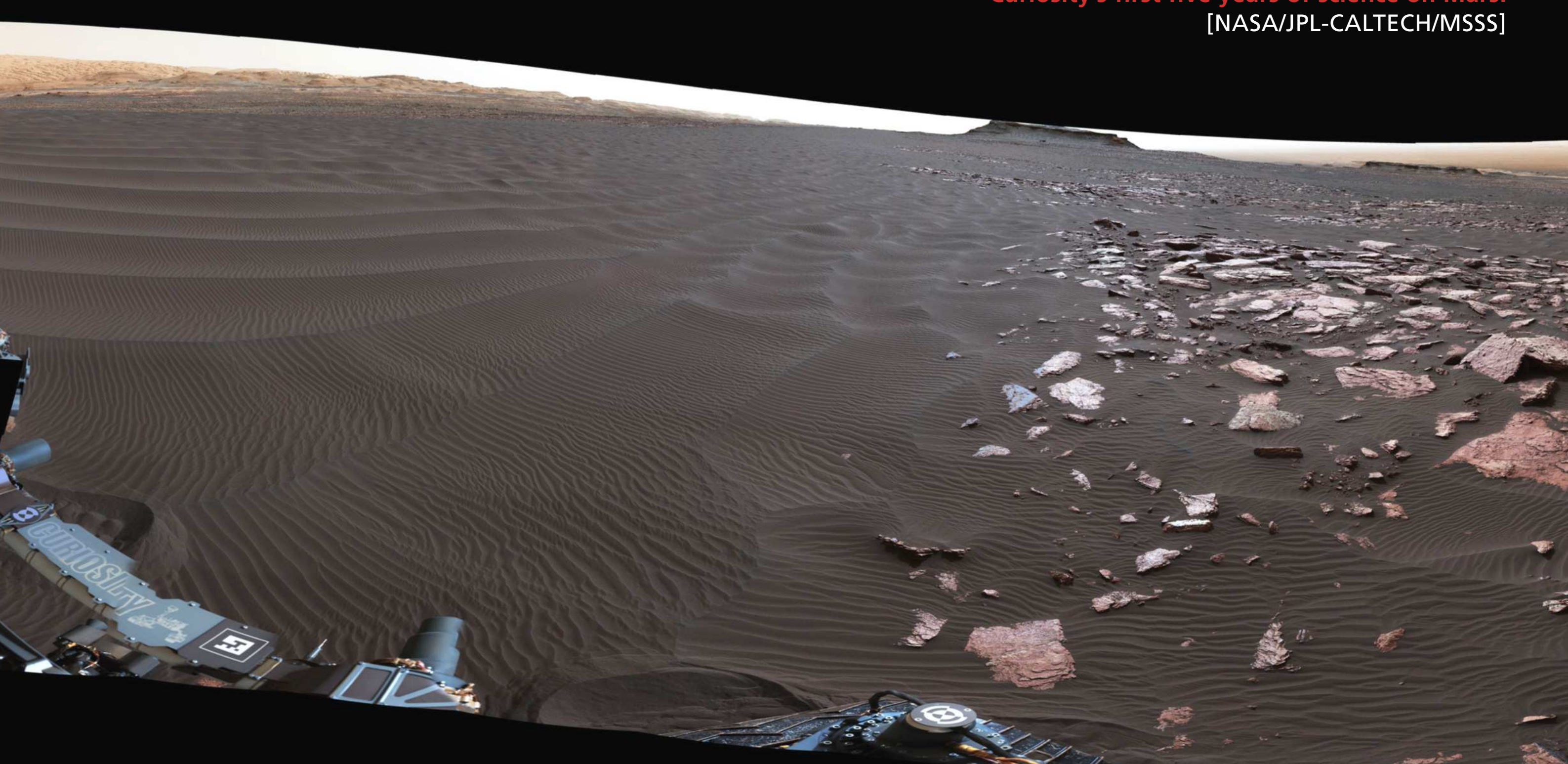
'Ireson Hill' on Mount Sharp, Mars.
This dark mound, called "Ireson Hill," rises about 16 feet (5 meters) above redder layered outcrop material of the Murray formation on lower Mount Sharp, near a location where Curiosity rover examined a linear sand dune in February 2017. Researchers used the Mastcam on Feb. 2, 2017, during the 1,598th sol of Curiosity's work on Mars, to take the 41 images combined into this scene. The mosaic has been white-balanced so that the colors of the rock and sand materials resemble how they would appear under daytime lighting conditions on Earth. The view extends from west-southwest on the left to north-northwest on the right. The faint horizon in the distance beyond Ireson Hill is part of the rim of Gale Crater. [NASA/JPL-CALTECH/MSSS]

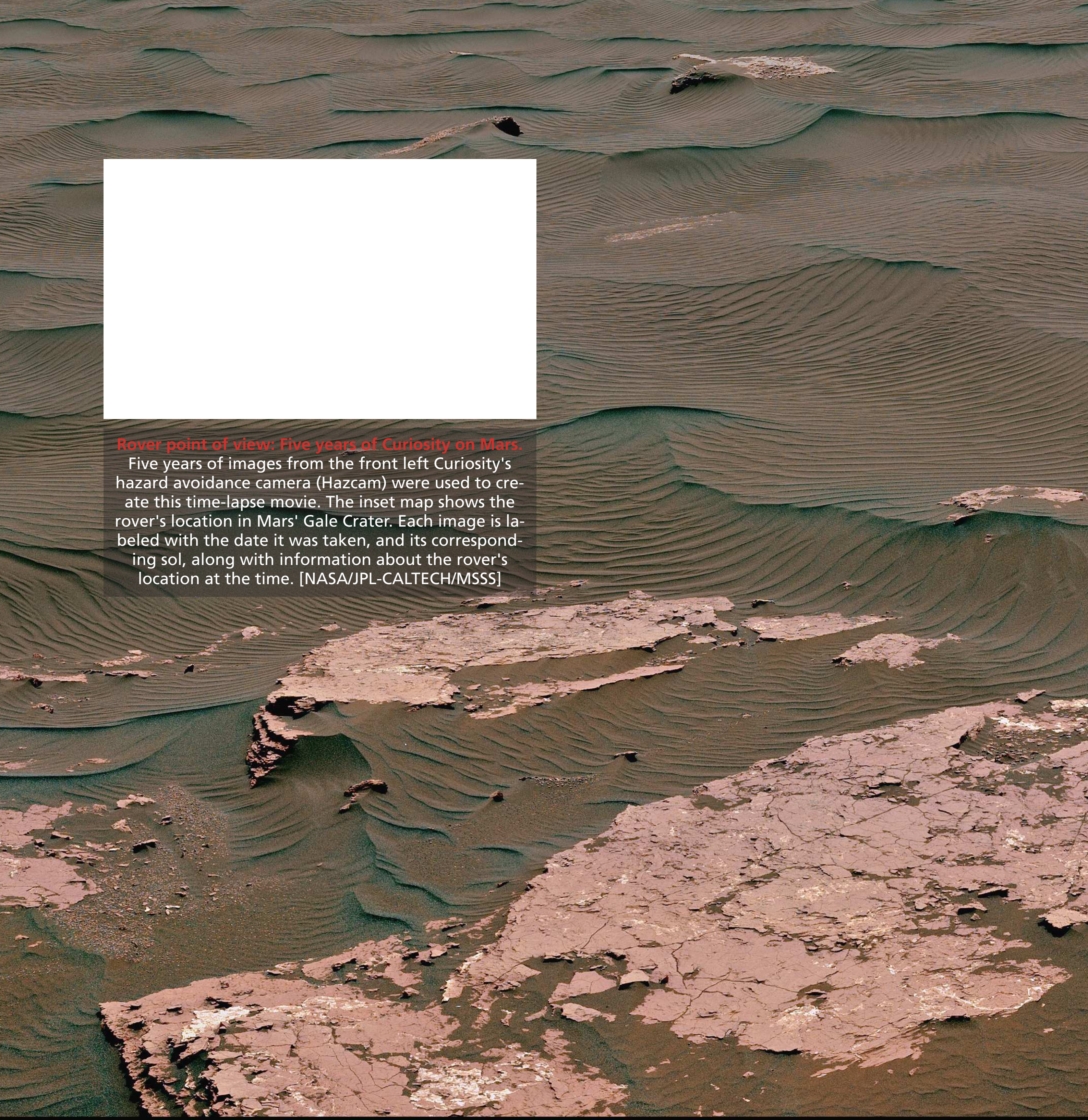


'Nathan Bridges Dune' on a Martian Mountain.
A rippled linear dune of dark Martian sand, "Nathan Bridges Dune," dominates this near full-circle panorama from the Mastcam of Curiosity. This dune was one research stop of the rover mission's campaign to investigate active Martian dunes. The feature was informally named in 2017 in memory of Nathan Bridges (1966-2017), a planetary scientist who was a leader of the Curiosity team's dune campaign. The scene combines 112 images taken with Mastcam's left-eye camera on Feb. 5, 2017, during the 1,601st sol of Curiosity's work on Mars. The panorama has been white-balanced so that colors of the rock and sand materials resemble how they would appear under daytime lighting conditions on Earth. The center is toward east-southeast and both ends are toward west-northwest. The dark butte on the horizon in the left half is "Ireson Hill." Upper Mount Sharp is on the horizon in the center. [NASA/JPL-CALTECH/MSSS]



Curiosity's first five years of science on Mars.
[NASA/JPL-CALTECH/MSSS]





Rover point of view: Five years of Curiosity on Mars.
Five years of images from the front left Curiosity's hazard avoidance camera (Hazcam) were used to create this time-lapse movie. The inset map shows the rover's location in Mars' Gale Crater. Each image is labeled with the date it was taken, and its corresponding sol, along with information about the rover's location at the time. [NASA/JPL-CALTECH/MSSS]

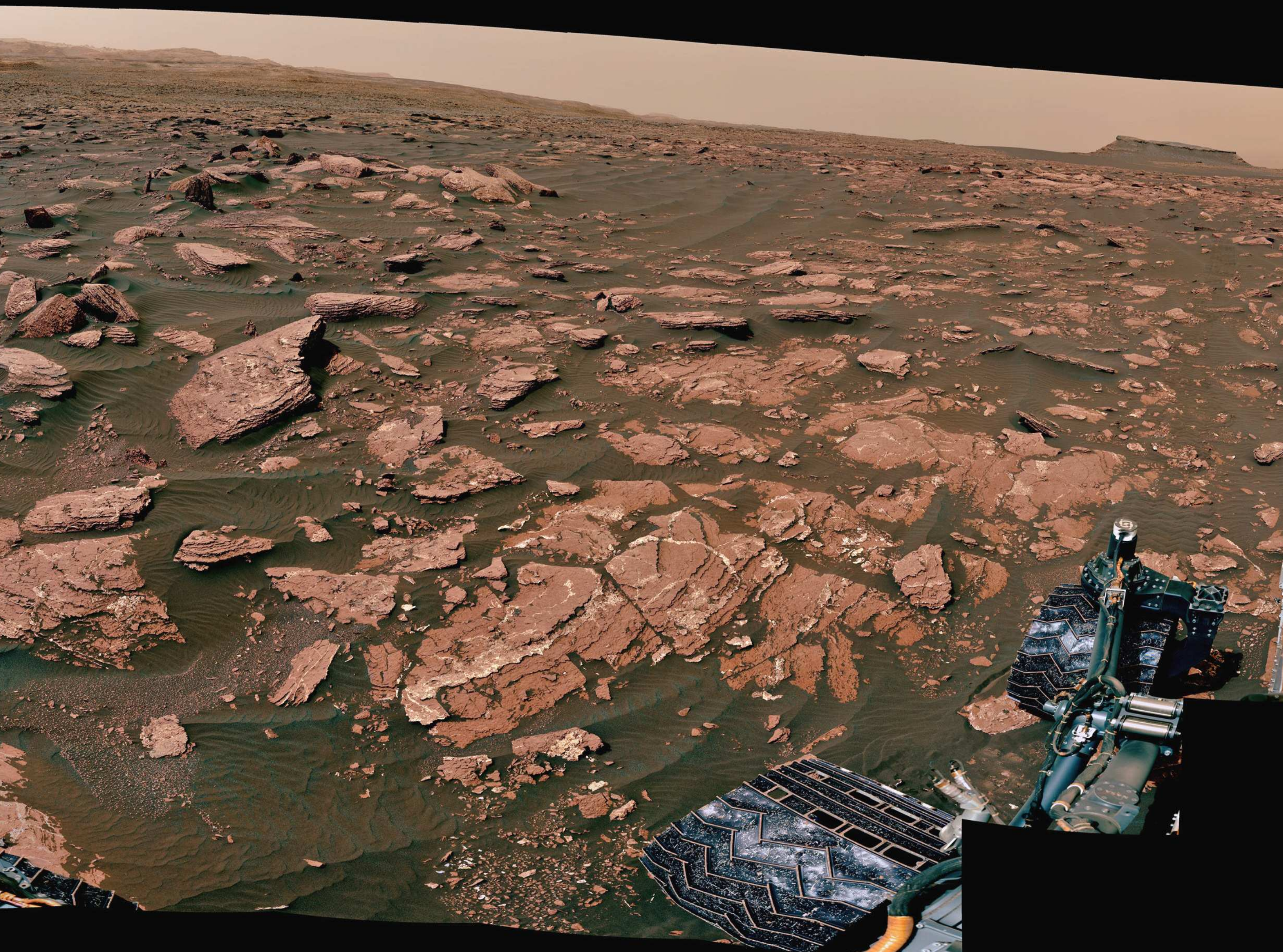
Textures where Curiosity rover studied a Martian dune.
This view from the Mastcam on Curiosity shows two scales of ripples, plus other textures, in an area where the mission examined a linear-shaped dune in the Bagnold dune field on lower Mount Sharp. The scene is an excerpt from a 360-degree panorama acquired on March 24 and March 25, 2017, (PST) during the 1,647th sol of Curiosity's work on Mars, at a location called "Ogunquit Beach."
Crests of the longer ripples visible in the dark sand of the dune are several feet (a few meters) apart. This medium-scale feature in active sand dunes on Mars was one of Curiosity's findings at the crescent-shaped dunes that the rover examined in late 2015 and early 2016. Ripples that scale are not seen on Earth's sand dunes. Overlaid on

those ripples are much smaller ripples, with crests about ten times closer together. Textures of the local bedrock in the foreground — part of the Murray formation that originated as lakebed sediments — and of gravel-covered ground (at right) are also visible.

The image has been white-balanced so that the colors of the colors of the rock and sand materials resemble how they would appear under daytime lighting conditions on Earth.

Malin Space Science Systems, San Diego, built and operates the Mastcam. NASA's Jet Propulsion Laboratory, a division of the Caltech in Pasadena, California, manages the Mars Science Laboratory Project for NASA's Science Mission Directorate, Washington. JPL designed and built the project's Curiosity rover. [NASA/JPL-CALTECH/MSSS]

Panorama with active linear dune in Gale Crater, Mars.
This mosaic from the Mastcam on Curiosity looks out over a portion of the Bagnold Dunes, which stretch for several miles. From early February to early April 2017, the rover examined four sites near linear dunes for comparison with what it found in late 2015 and early 2016 during its investigation of crescent-shaped dunes. This two-phase campaign is the first close-up study of active dunes anywhere other than Earth. The dark, rippled surface of a linear dune is visible at the center of the view and receding into the distance to the left. The bedrock of the Murray formation, made from sediments deposited in lakes billions of years ago, is in the foreground, along with some components of the rover. The location, called "Ogunquit Beach," is on the northwestern flank of lower Mount Sharp.



Northwest is at both ends of this almost full-circle panorama; southeast is at the center, where a higher portion of Mount Sharp dominates the horizon. Among the questions this Martian dune campaign is addressing is how winds shape the dunes into different patterns. Others include whether Martian winds sort grains of sand in ways that affect the distribution of mineral compositions, which also would have implications for studies of Martian sandstones. The 115 individual images that were combined into this mosaic were acquired by the Mast-cam's left-eye camera on March 24 and March 25, 2017, (PST) during the 1,647th sol of Curiosity's work on Mars. This mosaic is white-balanced so that the colors of the colors of the rock and sand materials resemble how they would appear under daytime lighting conditions on Earth. [NASA/JPL-CALTECH/MSSS]

NGC 1512 and NGC 1510, galactic David and Goliath

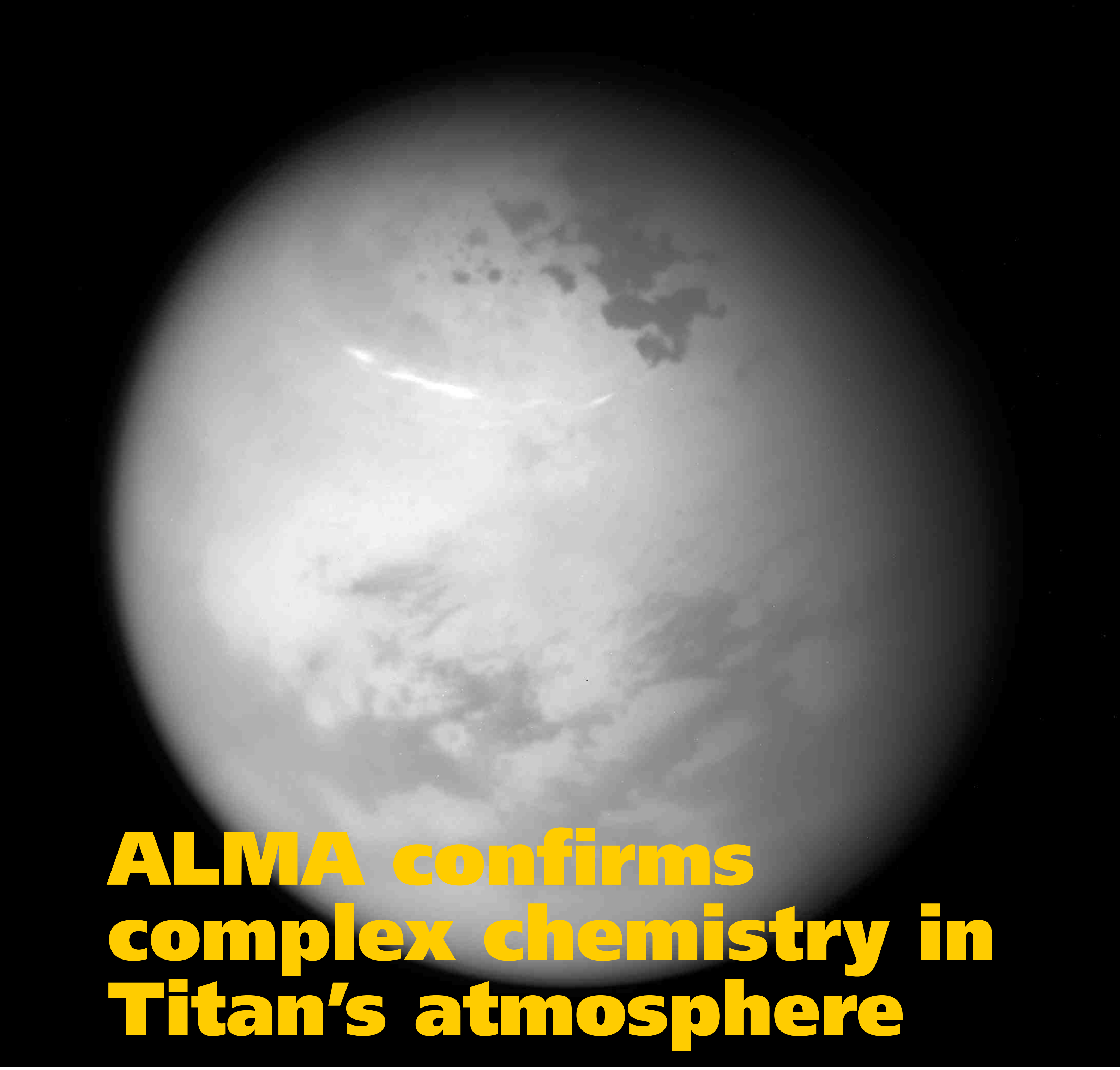
by NASA/ESA

The gravitational dance between two galaxies in our local neighbourhood has led to intriguing visual features in both as witnessed in this new NASA/ESA Hubble Space Telescope image. The tiny NGC 1510 and its colossal neighbour NGC 1512 are at the beginning of a lengthy merger, a crucial process in galaxy evolution. Despite its diminutive size, NGC 1510 has had a significant effect on NGC 1512's structure and amount of star formation. Galaxies come in a range of shapes and sizes, and astronomers use this fact to classify them based on their appearance.

NGC 1512, the large galaxy to the left in this image, is classified as a barred spiral, named after the bar composed of stars, gas and dust slicing through its centre. The tiny NGC 1510 to the right (on the following page), on the other hand, is a dwarf galaxy. Despite their very different sizes, each galaxy affects the other through gravity, causing slow changes in their appear-

This composite image, created out of two different pointings from Hubble, shows the barred spiral galaxy NGC 1512 (left, previous page) and the dwarf galaxy NGC 1510 (right). Both galaxies are about 30 million light-years away from Earth and currently in the process of merging. At the end of this process NGC 1512 will have cannibalised its smaller companion. [ESA/Hubble, NASA]

ances. The bar in NGC 1512 acts as a cosmic funnel, channelling the raw materials required for star formation from the outer ring into the heart of the galaxy. This pipeline of gas and dust in NGC 1512 fuels intense star birth in the bright, blue, shimmering inner disc known as a circumnuclear starburst ring, which spans 2400 light-years. Both the bar and the starburst ring are thought to be at least in part the result of the cosmic scuffle between the two galaxies — a merger that has been going on for 400 million years. NGC 1512, which has been observed by Hubble in the past, is also home to a second, more serene, star-forming region in its outer ring. This ring is dotted with dozens of HII regions, where large swathes of hydrogen gas are subject to intense radiation from nearby, newly formed stars. This radiation causes the gas to glow and creates the bright knots of light seen throughout the ring. Remarkably, NGC 1512 extends even further than we can see in this image — beyond the outer ring — displaying malformed, tendril-like spiral arms enveloping NGC 1510. These huge arms are thought to be warped by strong gravitational interactions with NGC 1510 and the accretion of material from it. But these interactions are not just affecting NGC 1512; they have also taken their toll on the smaller of the pair. The constant tidal tugging from its neighbour has swirled up the gas and dust in NGC 1510 and kick-started star formation that is even more intense than in NGC 1512. This causes the galaxy to glow with the blue hue that is indicative of hot new stars. NGC 1510 is not the only galaxy to have experienced the massive gravitational tidal forces of NGC 1512. Observations made in 2015 showed that the outer regions of the spiral arms of NGC 1512 were indeed once part of a separate, older galaxy. This galaxy was ripped apart and absorbed by NGC 1512, just as it is doing now to NGC 1510. Together, the pair demonstrate how interactions between galaxies, even if they are of very different sizes, can have a significant influence on their structures, changing the dynamics of their constituent gas and dust and even triggering starbursts. Such interactions between galaxies, and galaxy mergers in particular, play a key role in galactic evolution.



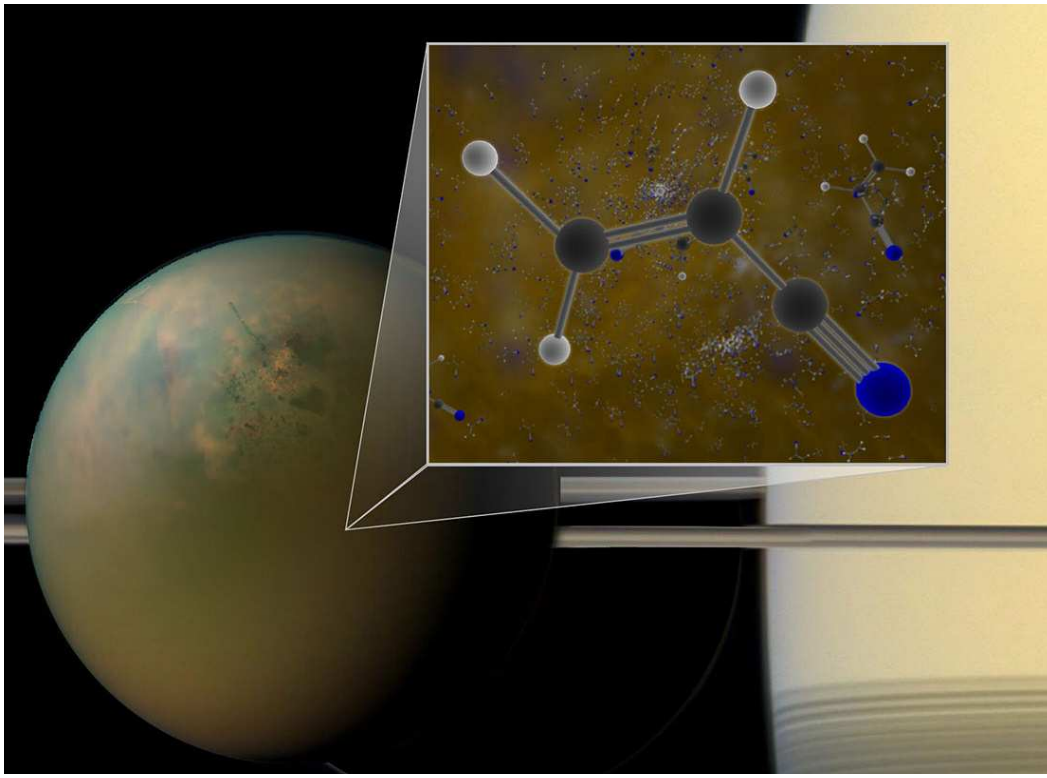
ALMA confirms complex chemistry in Titan's atmosphere

by ALMA Observatory

Saturn's largest moon, Titan, is one of our solar system's most intriguing object and Earth-like bodies. It is nearly as large as Mars and has a hazy atmosphere made up mostly of nitrogen with a smattering of organic, carbon-based molecules, including methane (CH_4) and ethane (C_2H_6). Planetary scientists theorize that this chemical make-up is similar to Earth's primordial atmosphere. The conditions on Titan, however, are not conducive to the formation of life as we know it; it's simply too cold. At ten times the distance from the Earth to the Sun, Titan is so cold that liquid methane rains onto its solid icy surface, forming rivers, lakes, and seas. These pools of hydrocarbons, however, create a unique environment that may help molecules of vinyl cyanide (C_2H_3CN) link together to form membranes, features resembling the lipid-based cell membranes of living organisms on Earth.

NASA's Cassini spacecraft sees bright methane clouds drifting in the summer skies of Saturn's moon Titan, along with dark hydrocarbon lakes and seas clustered around the north pole. [NASA/JPL-Caltech/Space Science Institute]

Astronomers using archival data from the Atacama Large Millimeter/submillimeter Array (ALMA), which was collected over a series of observations from February to May 2014, have found compelling evidence that molecules of vinyl cyanide are indeed present on Titan and in significant quantities. *"The presence of vinyl cyanide in an environment with liquid methane suggests the intriguing possibility of chemical processes that are analogous to those important for life on Earth,"* said Maureen Palmer, a researcher at NASA's Goddard Space Flight Center in Greenbelt, Maryland, and lead author on a paper published in *Science Advances*. Previous studies by NASA's Cassini spacecraft, as well as laboratory simulations of Titan's atmosphere, inferred the likely presence of vinyl cyanide on Titan, but it took ALMA to make a definitive detection. By reviewing the archival data, Palmer and her colleagues found three distinct signals – spikes in the millimeter-wavelength spectrum – that correspond to vinyl cyanide. These telltale signatures originated at least 200 kilometers above the surface of Titan.



Archival ALMA data have confirmed that molecules of vinyl cyanide reside in the atmosphere of Titan, Saturn's largest moon. Titan is shown in an optical (atmosphere) infrared (surface) composite from NASA's Cassini spacecraft. In a liquid methane environment, vinyl cyanide may form membranes. [B. Saxton (NRAO/AUI/NSF); NASA]

Titan's atmosphere is a veritable chemical factory, harnessing the light of the Sun and the energy from fast-moving particles that orbit around Saturn to convert simple organic molecules into larger, more complex chemicals.

"As our knowledge of Titan's chemistry grows, it becomes increasingly apparent that complex molecules arise naturally in environments similar to those found on the early Earth, but there are important differences," said Martin Cordiner, also with NASA's Goddard Space Flight Center and a co-author on the paper.

For example, Titan is much colder than Earth at any period in its history. Titan averages about 95 kelvins (-178°C), so water at its surface remains frozen. Geologic evidence also suggests that the early Earth had high concentrations of carbon dioxide (CO_2); Titan does not. Earth's rocky surface was also frenetically active, with extensive volcanism and routine asteroid impacts, which would have affected the evolution of our atmosphere. In comparison, Titan's icy crust appears quite docile.

"We are continuing to use ALMA to make further observations of Titan's atmosphere," concluded Conor Nixon, also with NASA's Goddard Space Flight Center and a co-author on the paper. *"We are looking for new and more complex organic chemicals as well as studying this moon's atmospheric circulation patterns. In the future, higher-resolution studies will shed more light on this intriguing world and hopefully give us new insights into Titan's potential for prebiotic chemistry."*

The Adaptive Optics Facility sees first light

by ESO

The Adaptive Optics Facility (AOF) is a long-term project on ESO's Very Large Telescope (VLT) to provide an adaptive optics system for the instruments on Unit Telescope 4 (UT4), the first of which is MUSE (the Multi Unit Spectroscopic Explorer). Adaptive optics works to compensate for the blurring effect of the Earth's atmosphere, en-

The powerful lasers of the AOF. The four 22-watt laser beams make sodium atoms in the atmosphere glow, creating spots of light on the sky that mimic stars. [Roland Bacon]

abling MUSE to obtain much sharper images and resulting in twice the contrast previously achievable.
MUSE can now study even fainter objects in the Universe. “Now, even when the weather conditions are not perfect, astronomers can still get superb image quality thanks to the AOF,” explains Harald Kuntschner, AOF Project Scientist at ESO.

Following a battery of tests on the new system, the team of astronomers and engineers were rewarded with a series of spectacular images. Astronomers were able to observe the planetary nebulae IC 4406, located in the constellation Lupus (The Wolf), and NGC 6369, located in the constellation Ophiuchus (The Serpent Bearer).

The MUSE observations using the AOF showed dramatic improvements in the sharpness of the images, revealing never before seen shell structures in IC 4406.
The AOF, which made these observations possible, is composed of many parts working together. They include the Four Laser Guide Star Facility (4LGSF) and the very thin deformable secondary mirror of UT4. The 4LGSF shines four 22-watt laser beams into the sky to make sodium atoms in the upper atmosphere glow, producing spots of light on the sky that mimic stars. Sensors in the adaptive optics module GALACSI (Ground Atmospheric Layer Adaptive Corrector for Spectroscopic Imaging) use these artificial guide stars to determine the atmospheric conditions.
One thousand times per second, the AOF system calculates the correction that must be applied to change the shape of the telescope’s deformable secondary mirror to compensate for atmospheric disturbances. In particular, GALACSI corrects for the turbulence in the layer of atmosphere up to one kilometre above the telescope. Depending on the conditions, atmospheric turbulence can vary with altitude, but studies have shown that the majority of atmospheric disturbance occurs in this “ground layer” of the atmosphere.
“The AOF system is essentially equivalent to raising the VLT about 900 metres higher in the air, above the most turbulent layer of atmosphere,” explains Robin Arsenault, AOF Project Manager. *“In the past, if we wanted sharper images, we would have had to find a better site or use a space telescope — but now with the AOF, we can create much better conditions right where we are, for a fraction of the cost!”*
The corrections applied by the AOF rapidly and continuously improve

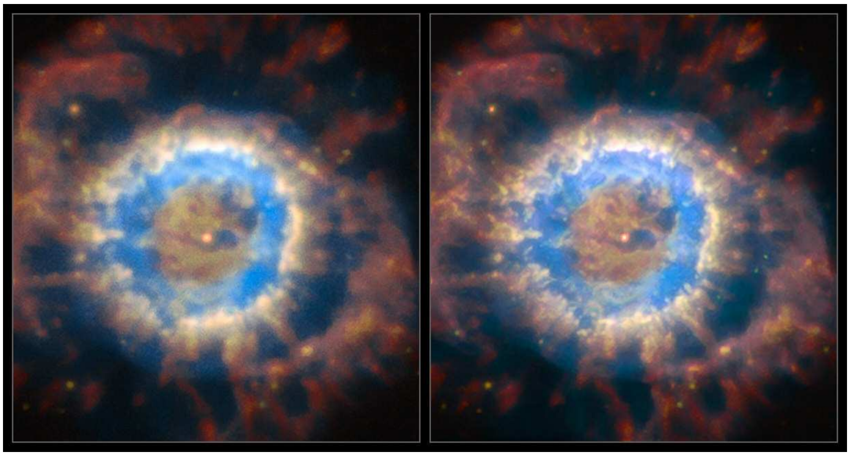
the image quality by concentrating the light to form sharper images, allowing MUSE to resolve finer details and detect fainter stars than previously possible. GALACSI currently provides a correction over a wide field of view, but this is only the first step in bringing adaptive optics to MUSE. A second mode of GALACSI is in preparation and is expected to see first light early 2018. This narrow-field mode will correct for turbulence at any altitude, allowing observations of smaller fields of view to be made with even higher resolution.

"Sixteen years ago, when we proposed building the revolutionary MUSE instrument, our vision was to couple it with another very advanced system, the AOF," says Roland Bacon, project lead for MUSE. *"The discovery potential of MUSE, already large, is now enhanced still further. Our dream is becoming true."*

One of the main science goals of the system is to observe faint objects in the distant Universe with the best possible image quality, which will require exposures of many hours. Joël Vernet, ESO MUSE and GALACSI Project Scientist, comments: *"In particular, we are interested in observing the smallest, faintest galaxies at the largest distances. These are galaxies in the making — still in their infancy — and are key to understanding how galaxies form."* Furthermore, MUSE is not the only instrument that will benefit from the AOF.

In the near future, another adaptive optics system called GRAAL will come online with the existing infrared instrument HAWK-I, sharpening its view of the Universe. That will be followed later by the powerful new instrument ERIS. "ESO is driving the development of these adaptive optics systems, and the AOF is also a pathfinder for ESO's Extremely Large Telescope," adds Arsenault. *"Working on the AOF has equipped us — scientists, engineers and industry alike — with invaluable experience and expertise that we will now use to overcome the challenges of building the ELT."*

The four Laser Guide Stars Facility points to the skies during the first observations using the AOF-equipped MUSE instrument. Adaptive optics assist ground-based telescopes by compensating for the blurring effect of the Earth's atmosphere on starlight. [Roland Bacon]



The planetary nebula NGC 6369 seen with natural seeing (left) and when the AOF is providing ground layer correction of the turbulent atmosphere (right). The AOF provides much sharper view of celestial objects and enables access to much finer and fainter structures. [ESO/P. Weilbacher (AIP)]


NortheK
Instruments - Composites - Optics
RITCHEY-CHRÉTIEN 250 MM
F/8.5 SUPRAX OPTICS FROM SCHOTT
CARBON STRUCTURE
NORTHEK CELL STABILOBLOK 25
FOCUSER FEATHER TOUCH FTF 2000 2"
WEIGHT 15 KG.
www.northek.it - www.facebook.com/northek.it - info@northek.it - phone +39 01599521