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 2019

K dwarfs, the best target for biosignatures

Space radiation – a deadly obstacle

- La Silla 50th anniversary culminates with total solar eclipse
- The early days of the Milky Way revealed by Gaia
- First 18 ELT primary mirror blanks arrive at Safran Reosc
- NEAR instrument sees first light
- “Moon forming” circumplanetary disk in a distant star system

The Tunguska event, now rarer than expected


NortheK
Instruments - Composites - Optics
DALL KIRKHAM 350 MM
F/20 23% OBSTRUCTION
SUPREMAX 33 PRECISION OPTICS FROM SCHOTT
CARBON STRUCTURE - 18-POINT FLOATING CELL
MOTORIZED FOCUSER 2.5" FEATHER TOUCH
VENTILATION AND SUCTION SYSTEM
OF THE BOUNDARY LAYER
WEIGHT 34 KG.
ALSO AVAILABLE IN THE VERSIONS
NEWTON F/4.1 WITH 3" CORRECTOR
RITCHEY CHRÉTIEN WITH F/9
CORRECTOR/REDUCER
CASSEGRAIN CLASSIC F/15
QUARTZ
www.northek.it - www.facebook.com/northek.it - info@northek.it - phone +39 01599521

FREE ASTRONOMY magazine

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

September-October 2019

English edition of the magazine

l'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

K dwarfs, the best target for biosignatures

by Michele Ferrara

revised by Damian G. Allis
NASA Solar System Ambassador

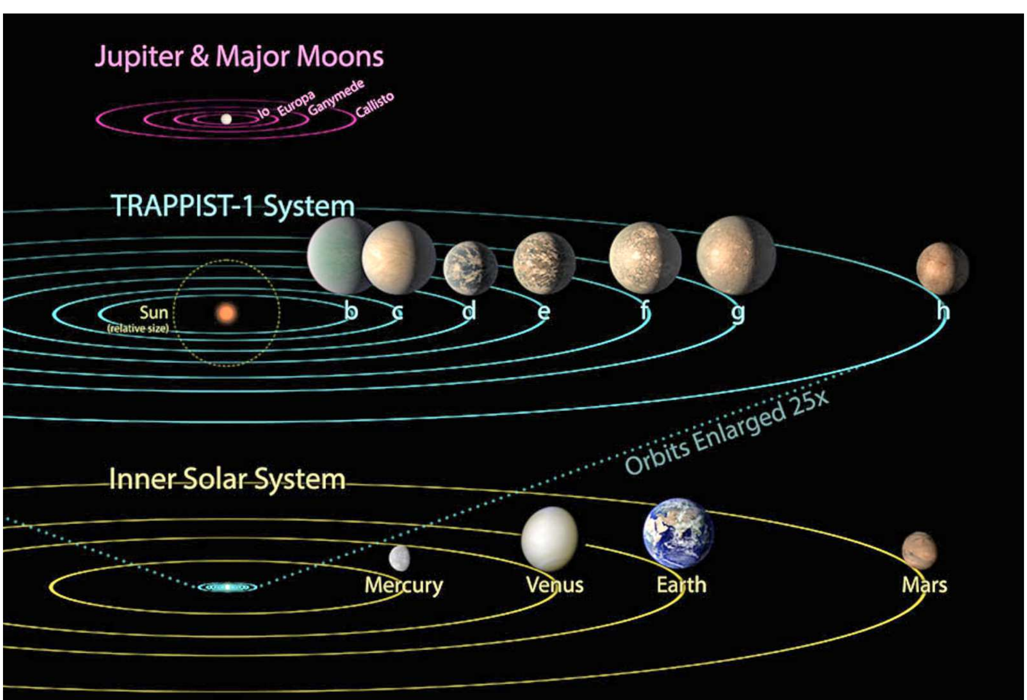
Almost all 4,000 exoplanets so far discovered and confirmed are certainly unsuitable for hosting life as we know it. Kepler-421 b, represented in the background, is an example of an inhospitable planet orbiting a solar-type star (G9/K0). [Harvard-Smithsonian, Center for Astrophysics/D. A. Aguilar]

For many years, we have believed that M dwarfs were the ideal stars around which to look for the first signs of extraterrestrial life. Now we have realized that planets in M dwarf habitable zones are subjected to extreme conditions and phenomena for a time incompatible with life as we know it. Researchers' attention has therefore moved towards K dwarfs, but we have yet to figure out where to point the telescopes.

Just over 10,000 days have passed since the discovery of the first exoplanet, and the 4,000 so far confirmed among the 3,000 known extrasolar systems have revealed an unpredicted variety of planetary systems. After the first random discoveries, researchers gained experience with those planets easiest to detect – the giant ones orbiting very small stars. Then, more targeted programs were launched, such as the prolific Kepler, to discover Earth-size planets orbiting in the habitable zones of solar-type "dwarf" stars, a term that includes spectral classes F, G and K. At the same time, more humble projects were also developed that continued using the easiest way to discover planets – find those that pass in front of the discs of the most classic dwarf stars, the so-called "red dwarfs" or M-types.

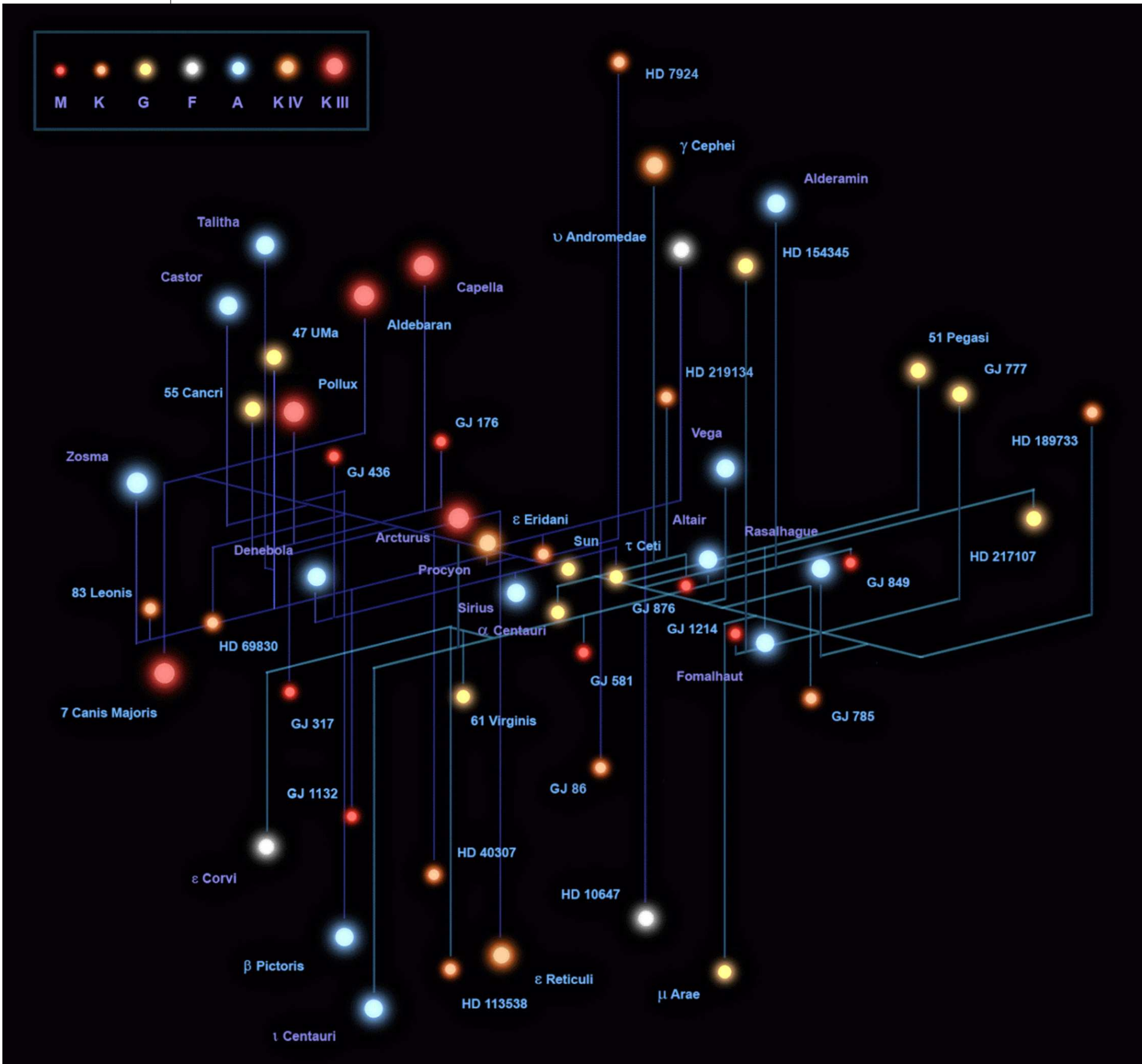
With all the research programs focused on identifying potentially habitable or inhabited planets, the overall goal was to search indiscriminately around stars of very different sizes, leaving out, at most, those of the first spectral types O, B and A, due to the fact that their brief stay on the main sequence does not give enough time for any planets around them to become definitely habitable. It is reasonable to suppose that the longer a star remains on the main sequence, the higher the probability that an orbiting Earth-like planet can host life forms. The smaller the initial mass of a star, the longer its permanence on the main sequence, so it goes without saying that M dwarfs present themselves as a rather interesting target, not only because their average life greatly exceeds the current age of the universe, but also because they are the most common stars in the galaxy, representing at least 75% of the total stellar population.

Furthermore, if we consider that M dwarfs' weak surface brightness and small mass favor the discovery of planets both with the transit method and the radial velocity variation method, it is no surprise that the largest

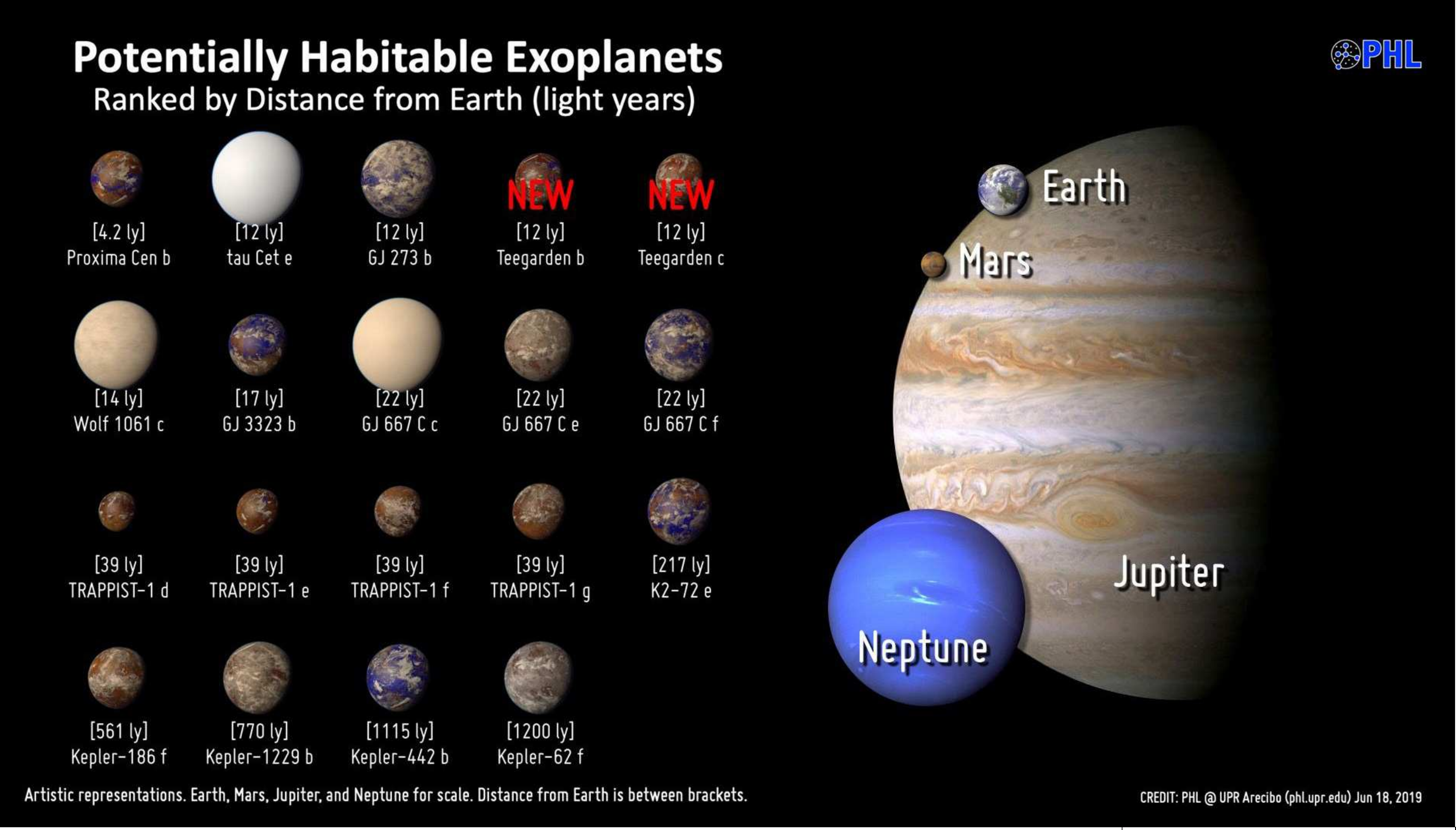


For a long time considered ideal stars around which to look for biosignatures, red dwarfs are instead proving increasingly unsuitable because of the violent flares that characterize them and that interact with their planetary atmospheres. Above, we see a representation of it. On the left, planetary systems comparison. On TRAPPIST-1 planets, many hopes were placed which are now fading. [NASA/JPL-Caltech] number of “candidate Earths” have been discovered around this type of dwarf. Among the 18 Earth-size exoplanets known today, one was discovered around a G dwarf, two around K dwarfs, and 15 around M dwarfs.

At first glance, it doesn’t matter if host stars are solar-type dwarfs or red dwarfs. What is important is that the planets are in the habitable zone, although in the case of M dwarfs, this means being very close to the star surface. Conversely, especially in recent years and through mostly theoretical studies, researchers have realized that things are not as obvious as they appeared up-to a few years ago. If the goal is to discover potentially habitable or inhabited planets, the worst places to look for them might just be M dwarf systems. They have evolutionary characteristics that conflict with the possibility of hosting life. During the first billion years of existence, in their pre-main sequence phase, these stars are much brighter and warmer than they are after reaching the main sequence. Moreover, for a few billions of years after

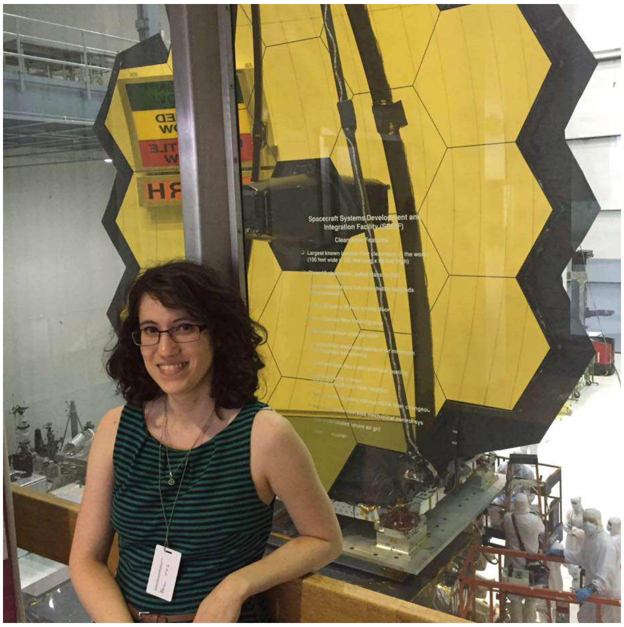


Familiar bright stars and selected exoplanetary host stars within 65 light-years of our Sun. Names of host stars appear in turquoise; names of stars without known planets appear in violet. [Backalley-astronomy]



their birth, but also later though less frequently, M dwarfs show a particularly violent surface activity, characterized by large-scale flares able to flood their habitable zone with intense X-ray and UV flows. Finally, the small size of the orbits of potential Earths hosted by M dwarfs speed up the synchronization between rotation and revolution periods, a process that makes almost all of a planetary surface inhospitable. These peculiarities entail harmful consequences for the habitability of planets destined to permanently orbit in the habitable zone of M dwarfs when the stars reach the main sequence. In fact, even before they reach main sequence status, all the water possibly present on their orbiting planets would be irremediably evaporated and missing in space. After reaching the main sequence, intense stellar flares would complete the planetary sterilization.

In the past, we were almost certain that the first biosignatures (molecules that can be related to the metabolic functions of living beings) would be found around an M dwarf. Today, it seems rational to heavily thin out this group of candidate Earths on the eve of the entry onto the scene of new and powerful telescopes precisely designed to directly observe the atmospheres of those planets. The hopes of identifying convincing biosignatures beyond our solar system then move towards G and K dwarfs. Unfortunately, even including some super-Earths at the lower limits of mass and diameter, we have no more than a handful of known planets that could theoretically offer environments comparable to terrestrial ones. After they have selected their targets, what will astronomers look for in those planetary atmospheres?



This is a list of the exoplanets that are more likely to have a rocky composition and maintain surface liquid water (i.e. 0.5 < Planet Radius ≤ 1.5 Earth radii or 0.1 < Planet Minimum Mass ≤ 5 Earth masses). They are represented artistically. On the side, Giada Arney, author of the study mentioned in the article, with the primary mirror of NASA's James Webb Space Telescope. [NASA]

An artist's concept of a planet orbiting in the habitable zone of a K-type star. [NASA Ames/JPL-Caltech/Tim Pyle]

Not being able to realistically imagine life other than as we know it on our planet, astronomers will look for biosignatures identical to terrestrial ones, having no idea what biosignatures might be associated with life forms based on elements other than carbon or metabolisms different from those of life on Earth.

The canonical biosignatures of modern Earth are molecular oxygen (O_2) and methane (CH_4). Their simultaneous presence in an evolved planetary atmosphere is considered a particularly strong biosignature. However, their mutual interaction implies that they have a relatively short lifetime in Earth-like atmospheres. In fact, stellar UV rays easily break down oxygen molecules, creating radicals that rapidly destroy methane molecules (to put it simply). Therefore, although these two molecules can be produced by abiotic processes, in the absence of biological processes capable of constantly replenishing the atmosphere, oxygen and methane could not simultaneously be present in quantities detectable in a planetary spectrum.

On Earth, methanogenesis probably began in the Hadean, over 3.5 billion years ago, thanks to the anaerobic metabolism of the first bacterial species. Already in that remote aeon, most of the methane present in the atmosphere was probably biogenic, despite the fact that the geological production of that gas was more prevalant

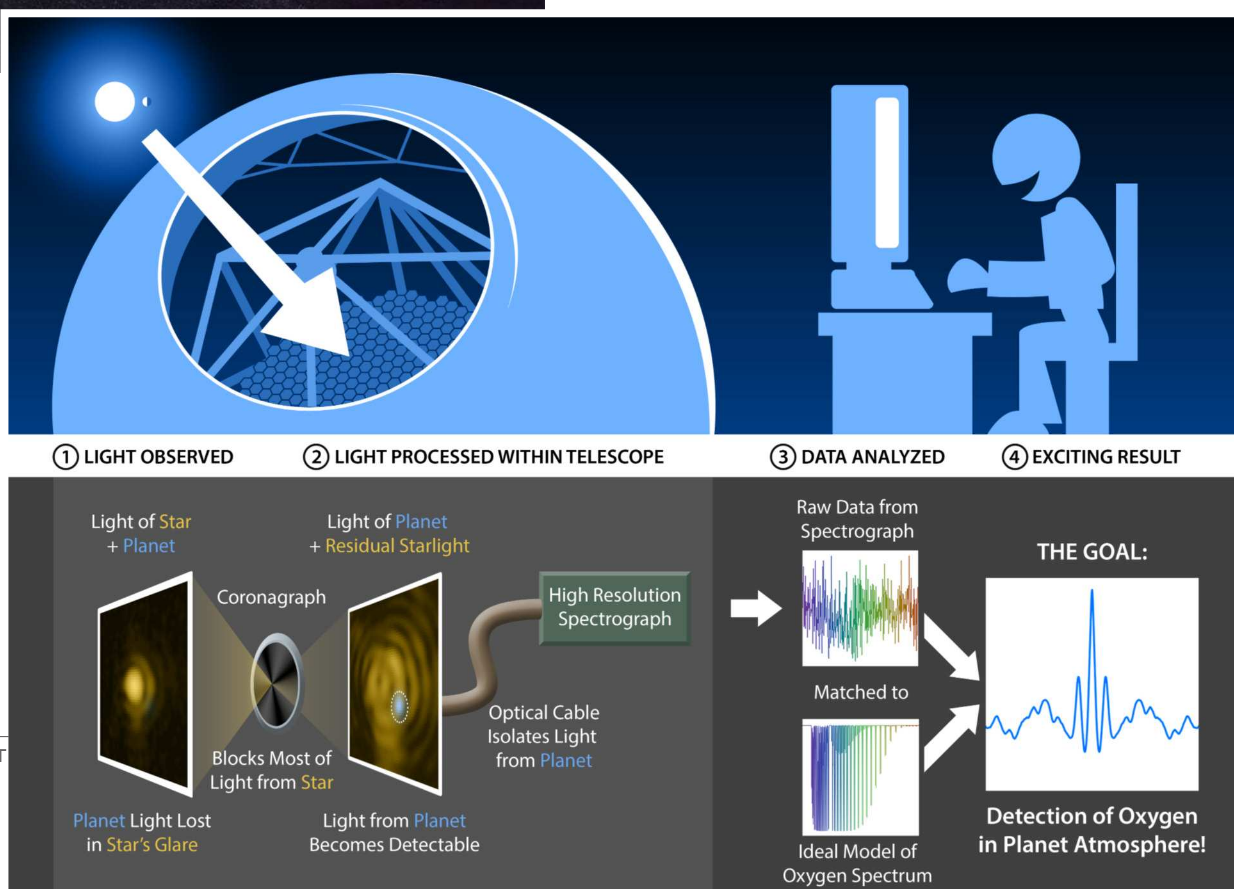
than today. Instead, there was still no trace of biogenic oxygen, whose production would have started about a half-billion years later (3 billion years ago or perhaps even earlier), with the advent of photosynthesis, the currently dominant metabolism on our planet. Until the middle of the Proterozoic (2.0-0.7 billion years ago), the abundance of atmospheric oxygen remained very scarce, reaching probably only 0.1% of the present level, and its presence would have been inferred from a possible faraway civilization only through the spectral recognition of ozone (O_3), a photochemical by-product of oxygen that produces a strong signal in the UV even when oxygen itself is too scarce to leave a trace.
In the last half-billion years, however, the disequilibrium in the atmospheric composition generated by life has become increasingly evident. Being able to analyze the terrestrial atmosphere through a spectroscope from a distant planet, you would

notice an abnormal abundance of oxygen and methane compared to atmospheric models for planets like ours in systems like ours. Although fluctuating, the disequilibrium has protracted long enough to be theoretically detectable from any point in the galaxy and beyond. If, somewhere out there, there is someone with adequate technology, he will already know that life forms exist on our planet.

We said above that, in the absence of a replenishing supply of oxygen and methane, the two molecules would soon disappear: the Sun, with the help of oxygen, would eliminate methane from the atmosphere in just ten years; an M dwarf would take a couple of centuries instead.

Not knowing in what concentrations biosignatures can be present in the atmosphere of another planet, searching for them around a star less efficient than the Sun at eliminating them could offer more chances for success. As we have seen, however, M dwarfs are not the ideal solution. Therefore, K dwarfs remain.

All the advantages of choosing this last spectral class have been treated in a theoretical study by Giada Arney of NASA's Goddard Space Flight Center in Greenbelt, Maryland,



An artist's rendering of the future Thirty Meter Telescope and a diagram that shows how new technology developed at Caltech will work: a coronagraph blocks a star's light, making orbiting planets easier to see and study. [NAOJ, Caltech/IPAC-TMT] A similar process is represented in the animation of the previous page. [NASA/JPL]

with the results recently appearing in *The Astrophysical Journal Letters*. The first reason for preferring K dwarfs is because they represent 12% of the main sequence stellar population, compared to about 8% of G dwarfs and 3% of F dwarfs. Moreover, K dwarfs are the longest-lived among the solar-type stars: 17-70 billion years, against 8-12 billion years for G dwarfs and 2-4 billion for F dwarfs (the stay time of the latter ones in the main sequence can certainly be considered insufficient for the development of particularly-evolved life).
Even the planet-star contrast ratio is more favorable for K dwarfs. A K2V, for example, has a brightness that is just 1/3rd that of the Sun (G2V), while a K6V emits just 1/10th the sunlight. It will, therefore, be less difficult to directly study a candidate Earth in the habitable zone of a K dwarf than a similar planet in the habitable zone of a G dwarf.
From a distant planet, the Earth would appear 10 billion times less bright than the Sun, but, if it was in the habitable zone of a K dwarf, it would be "only" 1 billion times less bright and proportionally less difficult to observe directly.
Compared to M dwarfs, K dwarfs offer two notable advantages: a decidedly shorter main pre-sequence phase of less than 100 million years and a much quieter surface

During the planned four-year primary mission, ESA's observatory PLATO will observe hundreds of thousands of stars, leading to the discovery and characterization of thousands of new exoplanets, some of which might lie in the habitable zone around Sun-like stars. [ESA/DLR]

activity, with a significantly smaller number of intense flares.
Recent measurements performed in the UV and X-ray spectrum of a group of young K dwarfs (10 to about 600 million years old) by a team of researchers led by Tyler Richey-Yowell (Arizona State University, Tempe) has demonstrated that any planets in their habitable zones would receive a flux of radiation 5 to 50 times less intense than they would receive orbiting around early M dwarfs and a flow from 50 to 1000 times less intense than they would receive orbiting around late M dwarfs (the smallest but also the most harmful stars).
In her theoretical study, Giada Arney used a computer model to simulate the chemistry and temperature of planetary atmospheres and to figure out how they respond to different host stars. Then, she entered the features of those atmospheres in a model that simulates the planetary spectrum and shows how Earth-like planets' spectra could appear in future telescopes that will be dedicated to those kinds of observations. Among these instruments, the most eagerly awaited are PLATO (PLAnetary Transits and Oscillations of stars satellite), HabEx (Habitable Exoplanet Observatory), and LUVOIR (Large UV Optical Infrared surveyor).
Giada Arney's simulations suggest that nearby mid-late K dwarfs could be excellent targets for biosignature research. In addition to the advantages already seen, these stars offer access to a wide range of wavelengths for planets in their habitable zones, also with the constraint of the so-called IWA (Inner Working Angle), which defines the smallest angular separation between a planet and a star to which the planet can be resolved and observed directly. This is the most relevant limit for future telescopes, which, in some ways, will be forced to target stars near the Sun. According to Giada Arney, the most interesting targets are 61 Cyg A and B (11.4 ly), Epsilon Indi (11.8 ly), Groombridge 1618 (15.9 ly), and HD 156026 (36 Ophiuchi C, 19.5 ly). The first three offer a signal-to-noise ratio 1.6 times better than Tau Ceti (11.9 ly), the nearest G dwarf after the Sun and Alpha Centauri A. The fourth offers a signal-to-noise ratio 1.4 times better than the G dwarf 82 Eridani (19.8 ly).
Unfortunately, so far, no planets potentially similar to ours have been discovered around these stars.
In short, the list of potential targets is sadly short and the only other two candidate Earths known in the habitable zone of K dwarfs (Kepler-442 b and Kepler-62 f) are 1100-1200 light-years away, well beyond the limits of an acceptable IWA.
Hoping to find biosignatures in such a small number of atmospheres (we are not even certain they resemble the terrestrial one) is a true act of faith, but somewhere we must start!

La Silla 50th anniversary culminates with total solar eclipse

by ESO

At 16:40 CLT, the Moon covered the face of the Sun, in a total solar eclipse visible from a 150-km-wide swathe of northern Chile, including ESO's La Silla Observatory, which celebrated half a century of astronomical research this year.

ESO, in collaboration with the Government of Chile, organised an outreach campaign that gave people the opportunity to experience this rare phenomenon from La Silla Observatory itself.

1000 visitors had access to the site, including more than 30 high school students and 30 senior citizens from La Serena, La Higuera and Coquimbo, the districts neighbouring the Observatory.

Another group of students came to La Silla from all over Chile. The youngsters were selected through a contest organised in collaboration with

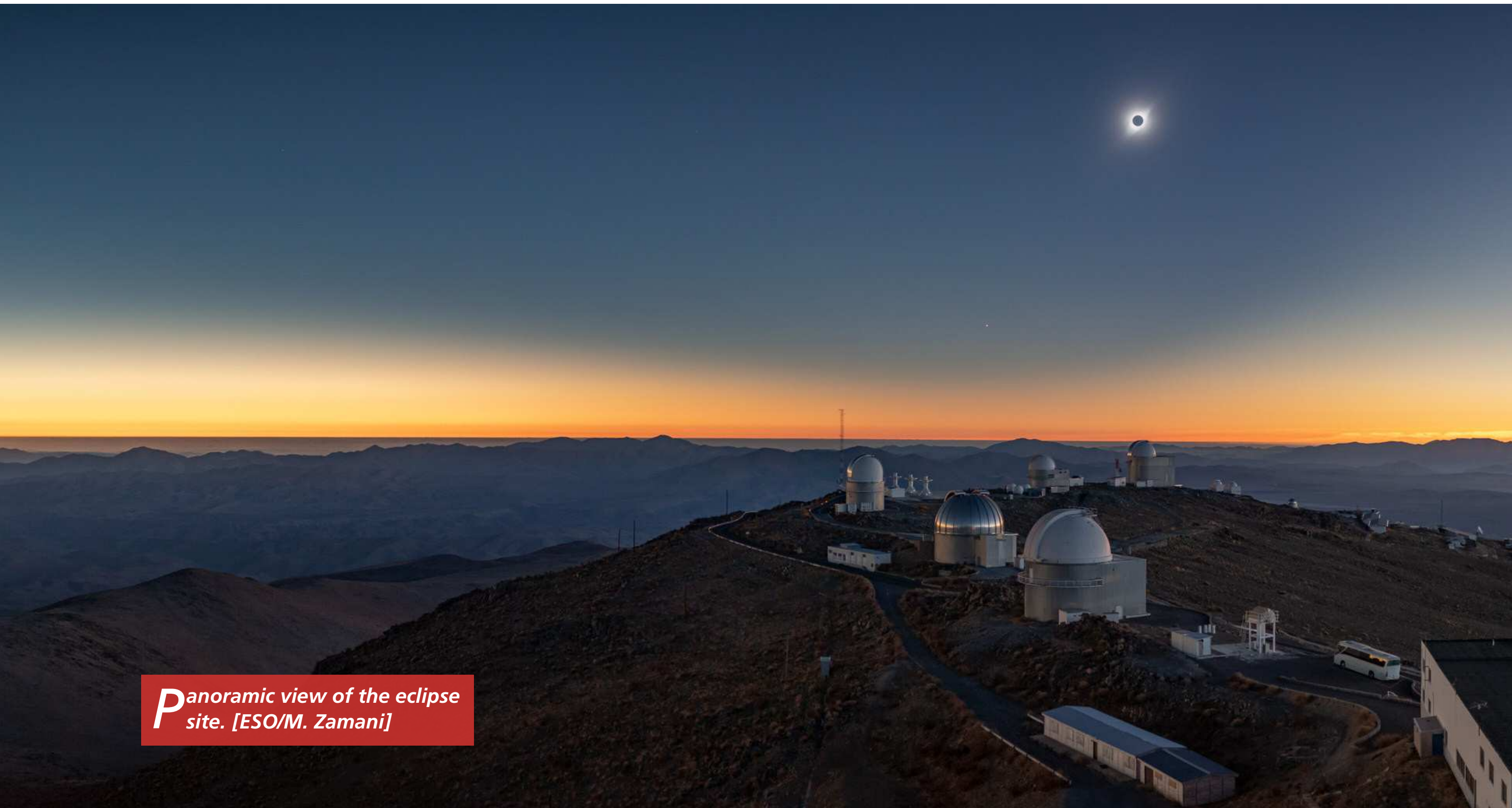
On 2 July 2019 a total solar eclipse passed over ESO's La Silla Observatory in Chile. The eclipse lasted roughly two and a half hours, with almost two minutes of totality at 20:39 UT, and was visible across a narrow band of Chile and Argentina. To celebrate this rare event ESO invited 1000 people, including dignitaries, school children, the media, researchers, and the general public, to come to the Observatory to watch the eclipse from this unique location. [ESO/R. Lucchesi]

the Chilean Ministry of Education. The students had to write a letter where they explained their interest in science and, particularly, in astronomy. The winners, each together with a parent, were rewarded with a fully paid trip to La Silla.
International and local media were also invited and about 60 representatives responded to the call. In addition, ESO webcast the eclipse online. Eight social media users were selected from 300 participants from ESON countries to participate in the #MeetESO second edition, a social media gathering taking the winners to all of ESO's sites. They are sharing their experience with the world on Twitter and Instagram, as well as on their own channels. A public competition dedicated to La Silla Observatory's 50th anniversary, #LaSilla50Years, also saw one person from ESO's

The President of the Republic of Chile, Sebastián Piñera, was greeted by ESO Director General Xavier Barcons when he visited ESO's La Silla Observatory on the occasion of the total solar eclipse on 2 July 2019 and the Observatory's 50 years of operation. The President was given a tour of La Silla's world-class facilities, celebrating a fruitful partnership between ESO and host country Chile. [ESO/M. Zamani]

Member States win a trip to Chile to visit our sites. *"People around the world made the voyage to Chile, hoping for an unrivalled view of the solar corona as the Moon passed between the Earth and the Sun, turning day into night for almost two minutes,"* explains Claudio Melo, ESO Representative in Chile. *"These visitors were rewarded with pristine Chilean skies and a per-*

Among the visitors who came to ESO's La Silla Observatory to view a total solar eclipse on 2 July 2019 were a number of outreach partners, who also visited ESO's other observatories in the country. [ESO/M. Zamani]



Panoramic view of the eclipse site. [ESO/M. Zamani]

The visitors ranged from local school children to international tourists, brought together to view the unusual and spectacular event at one of the world's leading astronomical observatories. [ESO/Romain Lucchesi]

fect view of the solar eclipse." Joining the many visitors at La Silla was the President of the Republic of Chile, Sebastián Piñera, who was welcomed by ESO's Director General, Xavier Barcons.

"We are delighted that the President chose to join us at La Silla on this very special day," said Xavier Barcons. *"The eclipse happened on the 50th anniversary of La Silla, an occasion to celebrate the strong and productive partnership between Chile and ESO. La Silla has played an extremely important role in the development of astronomy in Europe and Chile, and Chilean astronomers routinely use telescopes in La Silla for their scientific research."*

La Silla has been an ESO stronghold since the 1960s. Here, ESO operates two of the most productive 4-metre-class telescopes in the world.

The 3.58-metre New Technology Telescope (NTT) broke new ground in telescope engineering and design and was the first in the world to have a computer-controlled main mirror (active optics), technology developed at ESO and now applied to

most of the world's current large telescopes. The ESO 3.6-metre telescope is now home to the world's foremost extrasolar planet hunter in a ground-based observatory: the High Accuracy Radial velocity Planet Searcher (HARPS), a spectrograph with unrivalled precision.
The President enjoyed a tour of La Silla's facilities. *"We are stardust,"* exclaimed the President during the event. *"Today Chile is the world capital of astronomy and for this reason to be at La Silla Observatory today is very special."* The observatory's regular astronomical inhabitants were also on site to take advantage of existing observing infrastructure in novel ways. Seven projects with scientific or outreach goals took place during the eclipse, with some using pre-existing telescopes at La Silla, such as the NTT, ExTrA, TAROT and REM, and others using temporary setups. This follows a long tradition of using eclipses for scientific observations, such as the famous confirmation of General Relativity which took place 100 years ago.
The partial eclipse started at 15:23:50 CLT, with totality lasting 1 minute and 52 seconds from the La Silla summit, between 16:39:23 CLT and 16:41:15 CLT. The partial eclipse ended at 17:47:16 CLT, shortly before sunset.

Spectacular shot of the solar corona made by Petr Horálek. [ESO/P. Horálek] On the right, detail of the main protuberances visible on 2 July. [ESA–CESAR team]

In the background, all the phases of the eclipse photographed by Petr Horálek. [ESO/P. Horálek]

As the eclipse itself only occurred during the late afternoon, for the rest of the day visitors enjoyed a wide range of different activities, from tours of the La Silla telescopes to an engaging variety of talks, music and workshops. ESO astronomers and guides were on hand to engage with visitors throughout the day.

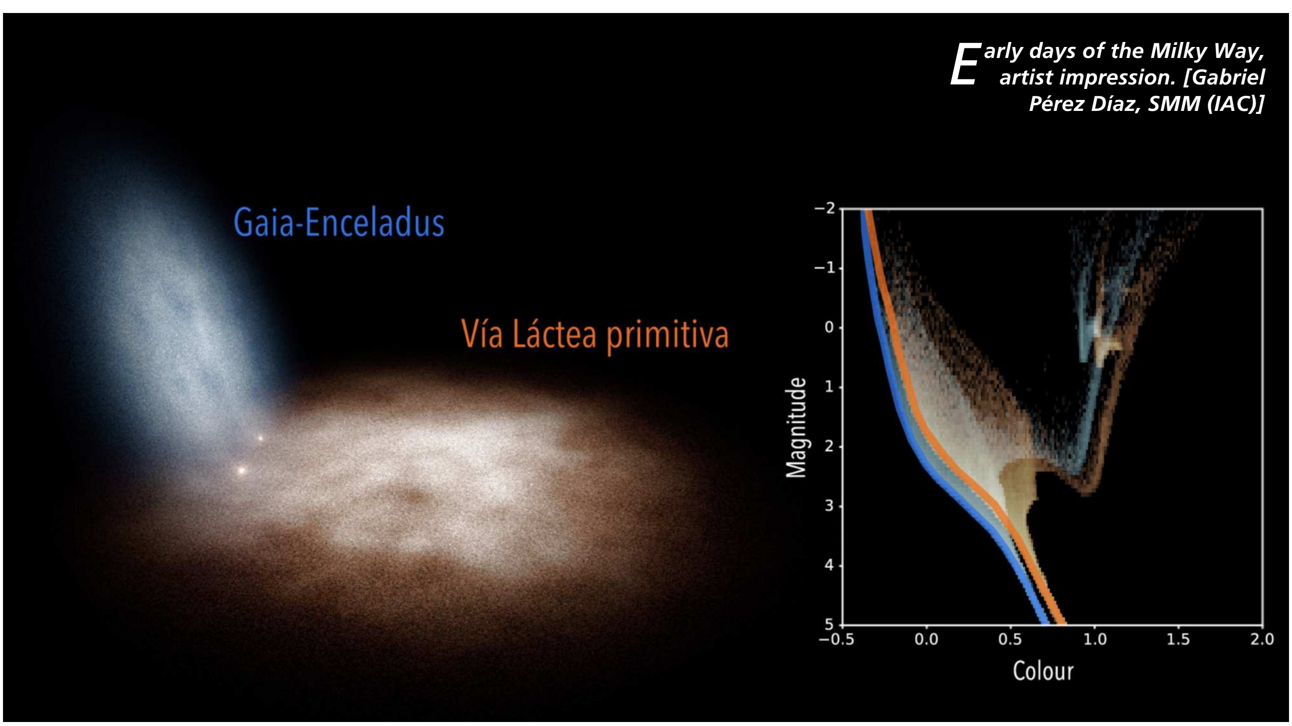
"Witnessing a total solar eclipse is a breathtaking experience that stays with you forever. Fond memories of today's event will remain in the hearts of our numerous guests at La Silla. This has been a unique moment in this unique observatory's history," concluded Xavier Barcons.

The last total solar eclipse visible from La Silla took place at the end of the 16th century, and the next will not be until the year 2231.

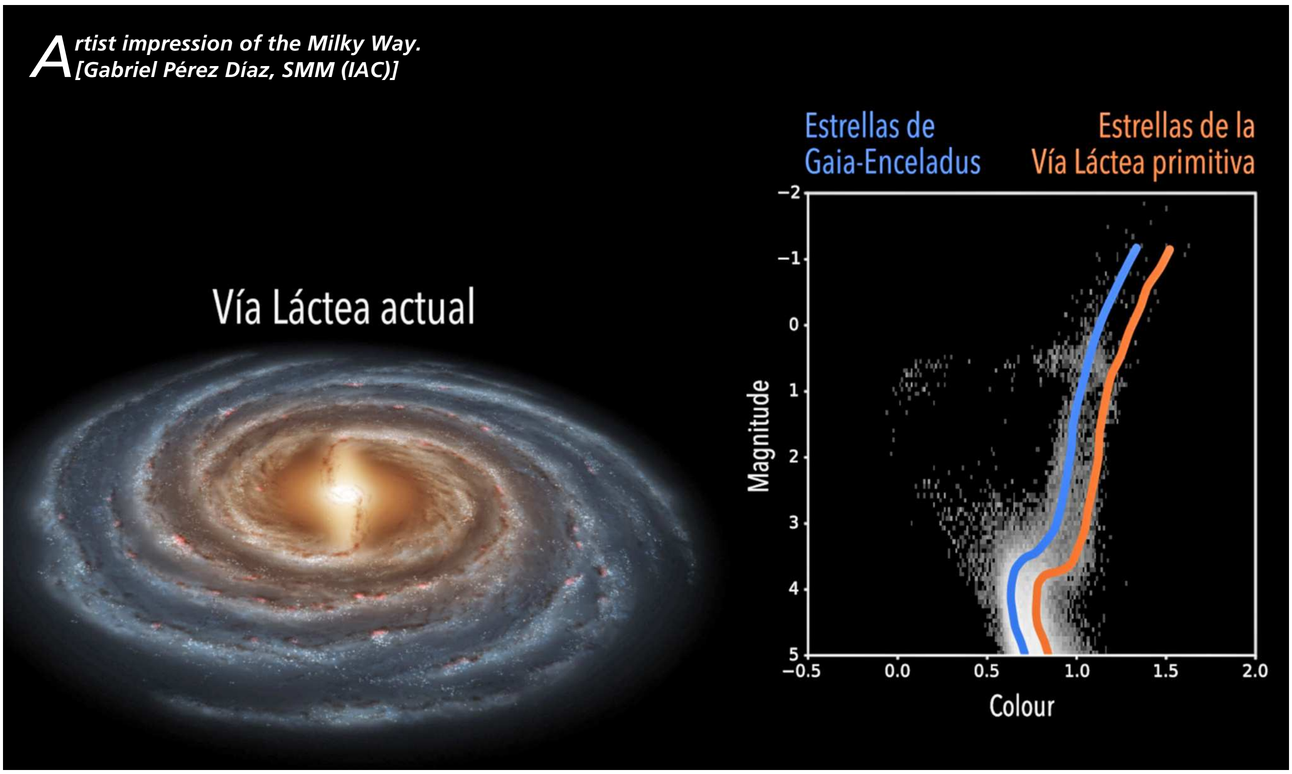
The early days of the Milky Way revealed by Gaia

by IAC

The universe 13 billion years ago was very different from the universe we know today. It is understood that stars were forming at a very rapid rate, forming the first dwarf galaxies, whose mergers gave rise to the more massive present-day galaxies, including our own. However, the exact chain of the events which produced the Milky Way was not known until now. Exact measurements of position, brightness and distance for around a million stars of our galaxy within 6,500 light-years of the Sun, obtained with the Gaia space telescope, have allowed a team from the IAC to reveal some of its early stages. *"We have analyzed, and compared with theoretical models, the distribution of colours and magnitudes (brightnesses) of the stars in the Milky Way, splitting them into several components, the so-called stellar halo (a spherical structure which surrounds spiral galaxies) and the thick disc (stars forming the disc of our Galaxy, but occupying a certain height range)"*, explains Carme Gallart, a researcher at the IAC and the



Early days of the Milky Way, artist impression. [Gabriel Pérez Díaz, SMM (IAC)]



Artist impression of the Milky Way. [Gabriel Pérez Díaz, SMM (IAC)]

first author of the article published in the journal *Nature Astronomy*.

Previous studies had discovered that the Galactic halo showed clear signs of being made up of two distinct stellar components, one dominated by bluer stars than the other.

The movement of the stars in the blue component quickly allowed us to identify it as the remains of a dwarf galaxy (Gaia-Enceladus) which impacted the early Milky Way. However, the nature of the red population and the epoch of the merger between Gaia-Enceladus and our Galaxy were unknown until now.

"Analyzing the data from Gaia has allowed us to obtain the distribution of the ages of the stars in both components and has shown that the two are formed by equally old stars, which are older than those of the thick disc," says IAC researcher and co-author Chris Brook. But if both components were formed at the same time, what differentiates one from the other? *"The final piece of the puzzle was given by the quantity of 'metals' (elements which are not hydrogen or helium) in the stars of one component or the other"* explains Tomás Ruiz Lara, an IAC researcher and another of the authors of the article. *"The stars in the blue component have a smaller quantity of metals than those of the red component"*. These findings, with the addition of the predictions of simulations which are also analyzed in the article, have allowed the researchers to complete the history of the formation of the Milky Way.

Thirteen billion years ago, stars began to form in two different stellar systems which then merged: one was a dwarf galaxy which we call Gaia-Enceladus, and the other was the main progenitor of our Galaxy, some four times more massive and with a larger proportion of metals. Some ten billion years ago there was a violent collision between the more massive system and Gaia-Enceladus. As a result, some of its stars and those of Gaia-Enceladus were set into chaotic motion, and eventually formed the halo of the present Milky Way. After that, there were violent bursts of star formation until six billion years ago, when the gas settled into the disc of the Galaxy and produced what we know as the "thin disc".

"All the cosmological predictions and observations of distant spiral galaxies similar to the Milky Way indicate that this violent phase of merging between smaller structures was very frequent" explains Matteo Monelli, a researcher at the IAC and a co-author of the article. Now we have been able to identify the specificity of the process in our own Galaxy, revealing the first stages of our cosmic history with unprecedented detail.

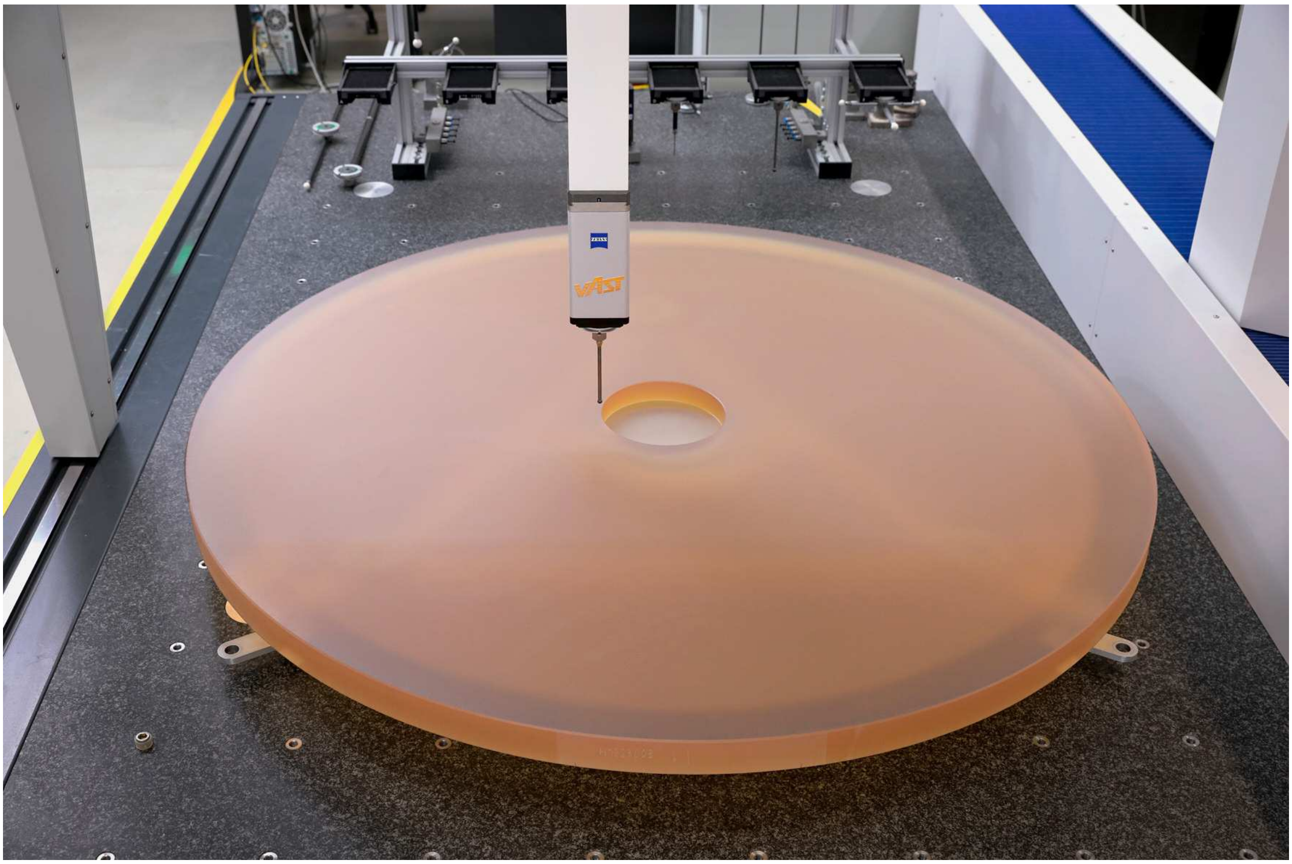
First 18 ELT primary mirror blanks arrive at Safran Reosc

by ESO

The first set of 18 blanks for the primary mirror of ESO's Extremely Large Telescope have arrived safely at Safran Reosc in Poitiers, France. The contracts for casting the blanks of the mirror segments, as well as polishing, mounting and testing them, were signed in 2017 with respectively the German company SCHOTT and the French company Safran Reosc, a subsidiary of Safran Electronics & Defense.

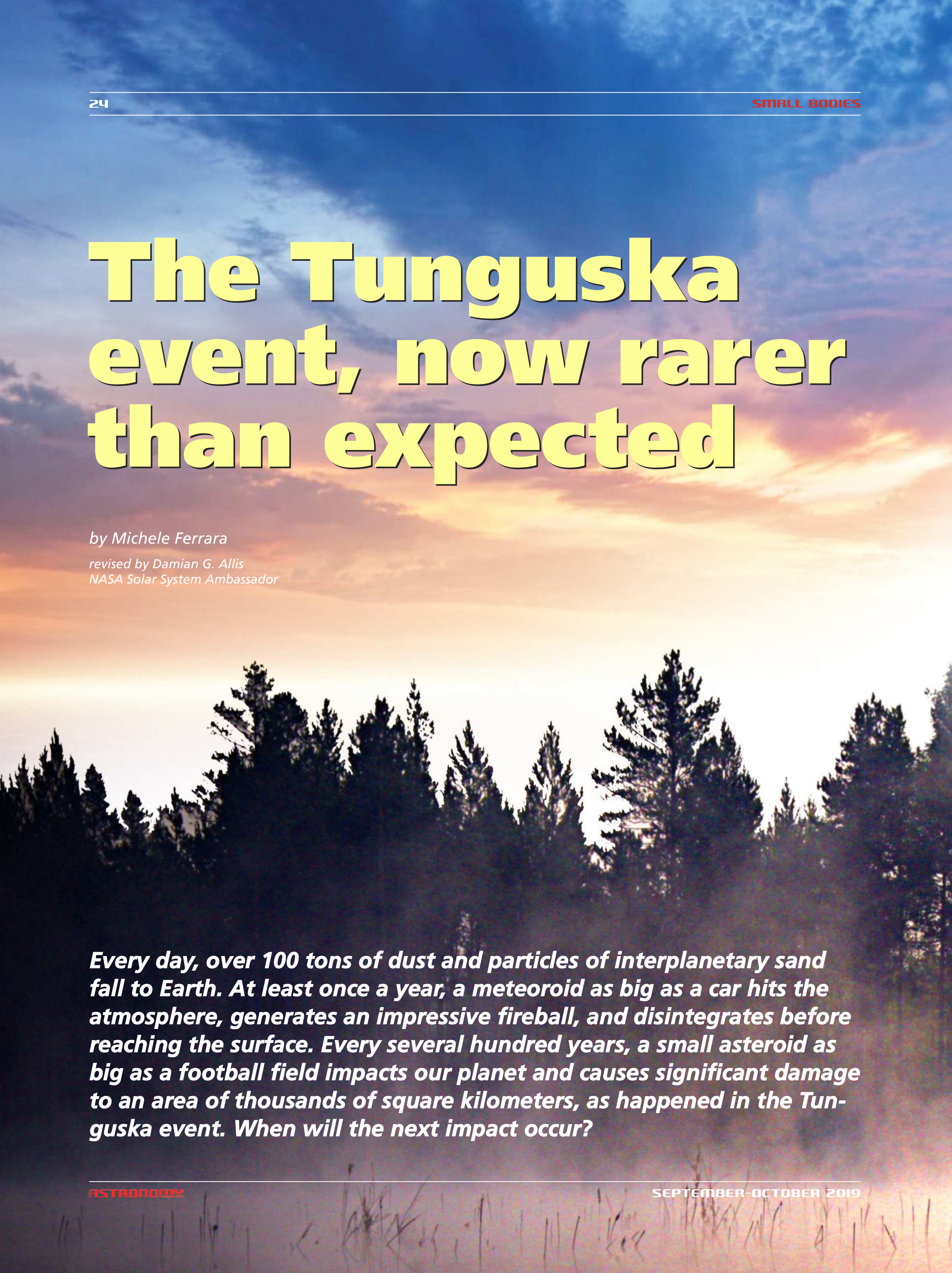
Mirror blanks are packed by six into a special wooden transport crate and six of these crates can fit inside a regular shipping container. Sophisticated

The shipping container with the first 18 ELT primary mirror blanks was sent from SCHOTT in Mainz, Germany, on 23 July and arrived at Safran Reosc the following day. [ESO/SCHOTT/Safran Reosc]



This is the first segment blank for mirror 1 (M1) of the ELT. Manufactured by SCHOTT, it was completed at the end of August 2018. M1 is the primary mirror of the ELT and, when completed, will be 39 metres in diameter and consist of 798 segments. The ELT is a revolutionary project that will allow astronomers to obtain images of larger planets and characterise their atmospheres, possibly enabling detection of biomarkers that could indicate life on other planets. [ESO]

shock sensors travel with the blanks to measure any sudden acceleration or shock that could affect the blanks. The shipping container with the first 18 blanks was sent from SCHOTT in Mainz, Germany, on 23 July and arrived at Safran Reosc the following day. The ELT mirror blanks are made of the low-expansion glass-ceramic Zerodur© and are circular, measuring 1.5 metres across and about 5 centimetres thick. The back of each blank is flat and the front surface is concave. The blanks come in three types with slightly differently shaped front surfaces, depending on the planned location of the segment in the primary mirror. The first primary mirror segments were cast by SCHOTT in 2018. SCHOTT manufactures the blanks to approximate shape so that Safran Reosc does not need to remove too much material during the polishing process. Safran Reosc will polish the blanks before they are cut into hexagons and receive a final precise polishing using *Ion Beam Figuring*. When it is completed, the primary mirror will comprise 798 hexagonal segments and will have a total light-collecting area of 978 m^2. In total, more than 900 segments will need to be cast and polished (including a spare set of 133 segments). Once built the ELT will be the largest ground-based telescope in operation. The telescope is being built at Cerro Armazones in the Atacama Desert of northern Chile. With a primary mirror almost 40 metres in diameter, the ELT will gather almost 100 million times more light than the human eye, which will allow scientists to tackle some of the biggest challenges in current astrophysics, such as the formation of the first stars, the assembly of the first galaxies, the characterisation of the atmospheres of Earth-like exoplanets, or the nature of dark matter and dark energy, among many other questions. ■



The Tunguska event, now rarer than expected

by Michele Ferrara

revised by Damian G. Allis
NASA Solar System Ambassador

Every day, over 100 tons of dust and particles of interplanetary sand fall to Earth. At least once a year, a meteoroid as big as a car hits the atmosphere, generates an impressive fireball, and disintegrates before reaching the surface. Every several hundred years, a small asteroid as big as a football field impacts our planet and causes significant damage to an area of thousands of square kilometers, as happened in the Tunguska event. When will the next impact occur?

In the background, a dramatic representation of the Tunguska event moments before the explosion of the asteroid in the Siberian sky.

Just over 111 years have passed since the famous Tunguska event, and during this long period, various hypotheses have been put forward as to what really happened. Even today in the scientific literature, research is reported that attempts to accurately determine the nature of the celestial body that caused the disaster and to calculate the probability that one day a similar event might be repeated in an area not necessarily uninhabited, as was the case at Tunguska. Among the most recent works on this topic is research inspired by a seminar held at NASA's Ames Research Center in Silicon Valley and sponsored by NASA's Planetary Defense Coordination Office. The results were published in a series of articles in a special issue of the magazine Icarus. Thanks also to the direct study of more recent minor events, such as the one of Chelyabinsk, the research as a whole has improved the scenario described so far by previous works.

To fully evaluate the new reports, however, it is necessary to go back over what happened in Central Siberia in the now-distant June 30, 1908. At 7:15 local time, in the sky above a plateau bathed by the river Podkamennaya Tunguska, in an almost inaccessible and uninhabited territory, a fireball appears that some witnesses described as red, bigger and brighter than the Sun, and accompanied by a trail of dust, thunder, and a terrifying final explosion. Houses trembled even at great distances from the explosion site, a pressure wave went around the Earth twice and, in the following nights, an extraordinary brightness of the sky was noticed both in all of Russia and in northern Europe. In England, in the night between June 30 and July 1st, the sky did not become dark, and in London you could read the newspaper at midnight. In Glasgow, Scotland, the night sky was so bright that only first and second magnitude stars were visible. Microbarographs of the Royal Meteorological Society recorded sharp

Photographs taken during the first expeditions of Leonid Kulik, showing glimpses of the devastation of the Siberian taiga, produced by the Tunguska event. The few trees left standing were called "telegraph poles."

changes in atmospheric pressure at the first light of day. Similar observations were made in Jena and Potsdam, in Germany, but also in Washington, where they appeared less intense than the European ones. The few Asian recordings were far more marked. Particularly interesting were the Potsdam measurements, which revealed both direct waves, recorded on the morning of June 30, and return waves, recorded on the morning of July 1st. Similar measurements were made by observation stations in Cambridge and Petersfield, England, thanks to which it was possible to establish that the pressure wave had passed at a speed of just over 300 meters per second, absolutely comparable to that produced in 1883 by the Krakatoa volcano explosion. Further east in Kansk, Siberia (about 500 km north of Mongolia), an observing station recorded violent seismographic and barographic oscillations and informed the Central Seismic Commission of St. Petersburg. The Commission, however, considered the report to be senseless since Siberia was not considered a seismic zone. Recordings of that same type performed by the Irkutsk Magnetic and Meteorological Observatory, another observational station in the region, made it possible to establish that the epicenter of the propagation of the seismic waves was in the north, in the middle of Siberia. Despite these and other personal and instrumental evidence, and despite the strange brightness of the night sky at the beginning of July, no one tried to delve into the nature of the extraordinary event. The fact of having presumably happened in a very inhospitable region, the limited means at the time available to scientists and explorers and, not least, some important historical events, all contributed to the

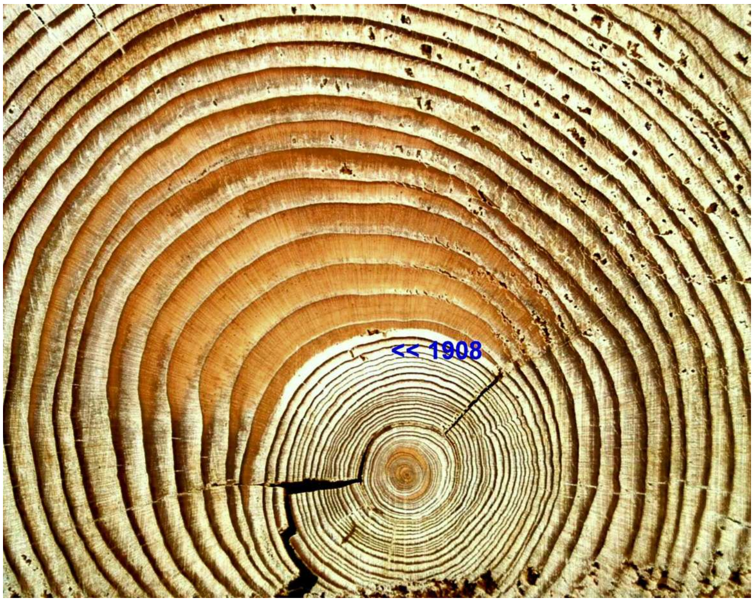
event itself falling into oblivion for over a decade. It was only in 1921 that a figure who more than others has linked his name to the Tunguska event, Leonid Kulik, came on the scene. Trained as a geologist, Kulik learned about the news about the discovery, later revealed to be fake, of a large meteorite near a section of the Trans-Siberian Railway. Believing it could be a fragment of the object that fell in 1908, he managed to organize a small scientific expedition, which evidently ended with nothing.

In 1927, after collecting more reliable documentation about the event, Kulik organized a second expedition hopeful to discover the crater of a large meteorite. He knew he had to reach the Tunguska region and was aware that the object had probably exploded in flight at a height of about ten kilometers, but he believed that some large fragments were still recognizable. Kulik pushed deep into the Siberian taiga until he reached an Evenky village called Vanavara, the closest town to the Tunguska event. With the help of local guides and after days of strenuous marching, Kulik reached the edge of a forest whose trees had been broken down and aligned radially with respect

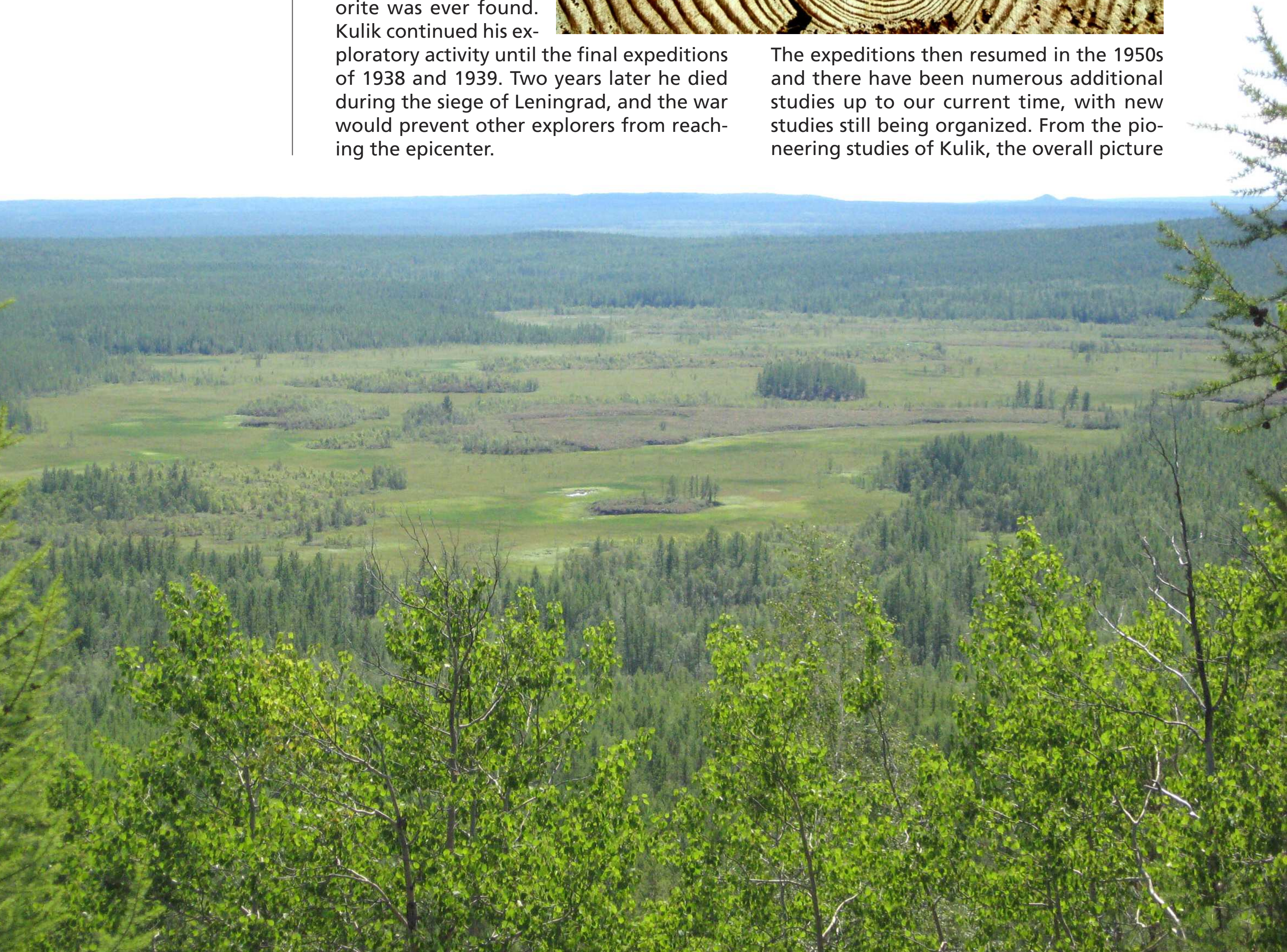
On the left, Leonid Kulik, the first and most obstinate investigator of the Tunguska event. Above, a stamp dedicated to him. Below, a video showing various scenes of the difficult expeditions organized by Kulik, in search of traces of the fall of a large meteorite.

The growth of the rings of the few surviving trees, found within a few kilometers of the epicenter of the Tunguska event, shows a depression that begins the year after the event and continues for another 4-5 years. Below, the area devastated in 1908 as it appears today.

to a hypothetical center, which the expedition was unable to reach. The goal of reaching the epicenter was instead pursued the following year, with a new expedition financed by the Academy of Sciences, and was then again in 1929. On those occasions, many cavities and small depressions were identified that could have concealed meteorite fragments, but, despite multiple excavations, no meteorite was ever found. Kulik continued his exploratory activity until the final expeditions of 1938 and 1939. Two years later he died during the siege of Leningrad, and the war would prevent other explorers from reaching the epicenter.

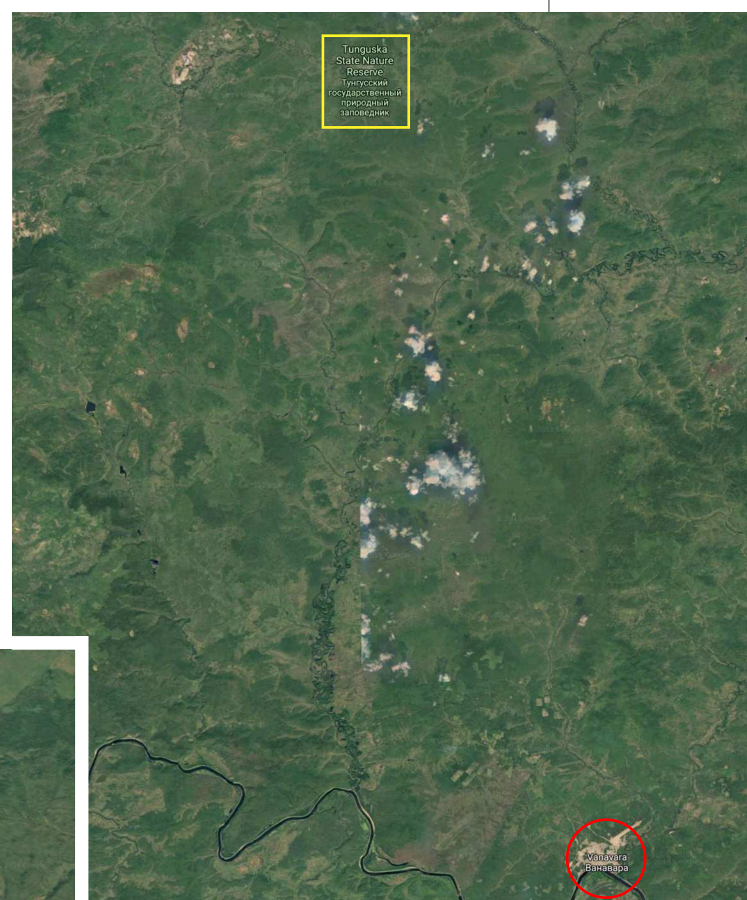


The expeditions then resumed in the 1950s and there have been numerous additional studies up to our current time, with new studies still being organized. From the pioneering studies of Kulik, the overall picture



has undergone some significant updates. The object that exploded in flight had to be a small rocky asteroid (although the cometary nucleus hypothesis has not been entirely ruled out), with an initial diameter between 30 and 60 meters, which traveled at least 15 km/s and which produced an energy of 5-20 megatons, exploding at a height between 5 and 10 km above the ground. The explosion devastated a surface are of over 2000 km^2, destroying upto 80 million trees. No fragments that could be associated with the asteroid have ever been found. Even if a single crater unequivocally attributable to the ground impact of an asteroid is never identified, studies from a decade ago propose Lake Cheko, located 8 km north of the epicenter, as a probable site of fall of a secondary fragment. This lake, half a kilometer long and about 300 meters wide, does not seem to have existed before 1908.

The very approximate knowledge of the physical parameters of the asteroid has never allowed for an accurate description of the dynamics of the Tunguska event; consequently, all the forecasts made in the past on the possible repetition of such an occurrence were suspect



Satellite views of the vast area affected by the transit and final explosion of the Tunguska asteroid. Vanavara, North-Northwest of Lake Baikal, was in 1908 the nearest town to the epicenter. [Google Maps]

The illustration on the right shows the perimeter of the Siberian area devastated by the Tunguska event with a red outline. The same perimeter was then superimposed on the metropolitan areas of three major US cities, to give an idea of what could happen if an event like that of 1908 were repeated today in a densely populated region. The animation below also extends the comparison to other major cities around the planet. [Asteroidday.org]

in their accuracy. The only thing known with certainty is the effects produced on the environment, of which there are many images and some videos. Being able to compare those effects with the aftermath of an even smaller event, but for which we have all the useful information to validate the models applicable to the Tunguska event, can get us a sufficiently precise idea of the mass, volume, density and composition of the small asteroid that triggered the disaster.

As we said at the beginning, the recent Chelyabinsk event offered this opportunity, becoming a sort of "Rosetta Stone" to better interpret the Tunguska event. Unlike previous studies that had taken into consideration a small subset of cases based on typical physical and dynamic properties, the new research has greatly expanded the series, including a new probabilistic asteroid impact risk model, to better evaluate asteroid trajectory, explosion energy and environmental effects. The model produced 50 million possible combinations, able to cover the entire range of properties of the impactor. All possible scenarios are sampled from probabilistic distributions representing our current knowledge of asteroid properties, entry trajectories, and size frequencies. The results show that Tunguska-type events can be produced by a wide range of impact scenarios and also suggest that objects with diameters of 70-80 meters and initial energies of 20-30 megatons are more likely to cause Tunguska-scale damage areas than objects at the lower end of the potential size range. Comparing these values to those previously considered closer to reality, it can be

deduced that if the Tunguska asteroid was larger than previously believed, events of this type must necessarily be less frequent than expected, since the number of existing asteroids decreases as the diameter increases. And, in fact, combining the results obtained by the Ames models with the most recent estimates of asteroid populations, researchers concluded that the average interval between Tunguska-like impacts should be on the order of millennia and not centuries, as hypothesized in the past. This data is certainly reassuring, but since human beings already inhabit around 10% of the Earth's surface, the probability that the next Tunguska event will occur above a built-up area, with obvious consequences, is far from negligible.

It will therefore be essential to continue and intensify the search for smaller and smaller asteroids, until a complete census of those whose orbits can intersect the Earth's orbit will be available.
Many telescopes are already engaged in this type of survey and others are about to start operations both on the ground and in orbit. Also, the knowledge of the structure and composition of the small bodies of the Solar System is important for a correct modeling of Tunguska-like events, and in this context, automatic missions such as Hayabusa and Rosetta are crucial. No effort will be superfluous in the attempt to avoid the only foreseeable and predictable natural disaster. ■

Lake Cheko is the only probable trace left by a fragment of the Tunguska asteroid. On the left, a three-dimensional computer simulation of the lake immediately after the impact, reconstructed based on topography and bathymetry data. The water level is kept about 40 meters lower than actuality for a better view of the bottom shape. [Institute of Marine Sciences, CNR] Below is how it looks today. [V. Romeiko]

NEAR instrument sees first light

by ESO

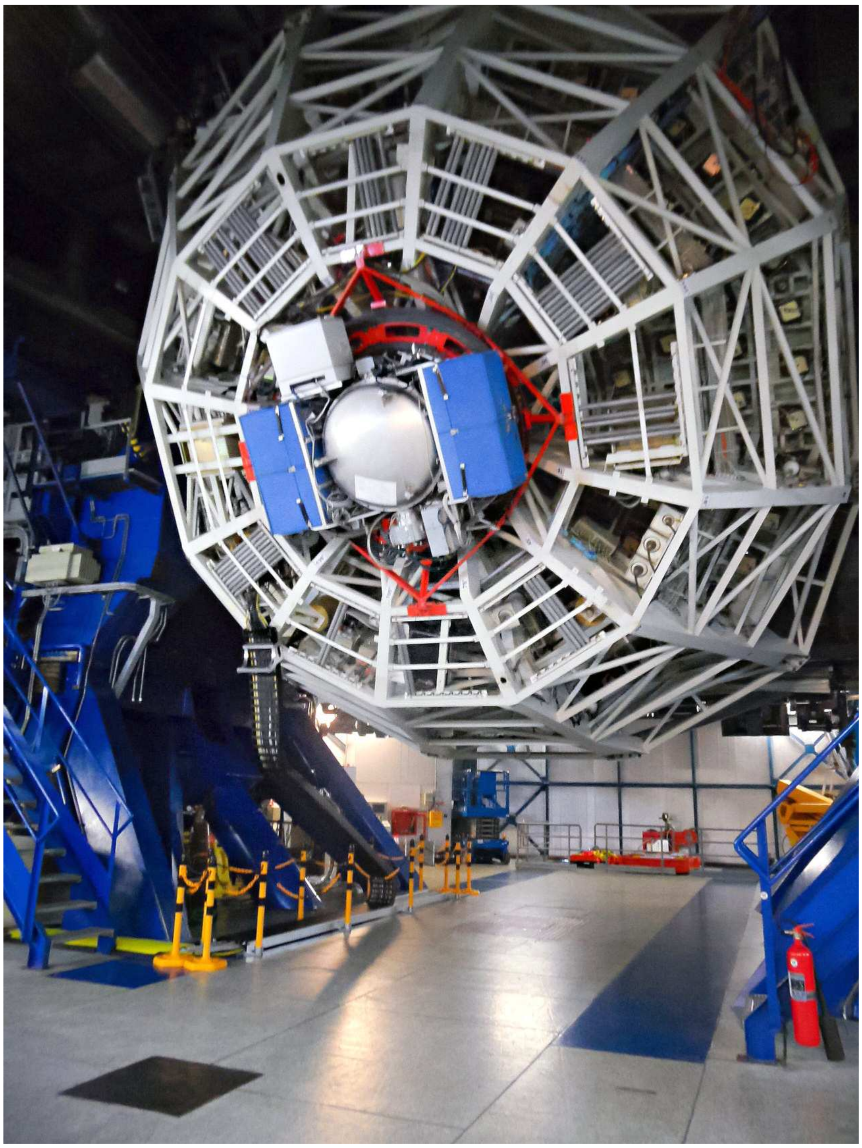
Breakthrough Watch, the global astronomical program looking for Earth-like planets around nearby stars, and the European Southern Observatory (ESO), Europe's foremost intergovernmental astronomical organisation, announced "first light" on a newly-built planet-finding instrument at ESO's Very Large Telescope in the Atacama Desert, Chile.

The instrument, called NEAR (Near Earths in the AlphaCen Region), is designed to hunt for exoplanets in our neighbouring star system, Alpha Centauri, within the "habitable zones" of its two Sun-like stars, where water could potentially exist in liquid form. It has been developed over the last three years and was built in collaboration with the University of Uppsala in Sweden, the University of Liège in Belgium, the California Institute of Technology in the US, and Kampf Telescope Optics in Munich, Germany.

Since 23 May ESO's astronomers at ESO's Very Large Telescope (VLT) performed a ten-day observing run to establish the presence or absence of one or more planets in the star system. Observations ended on 11 June.

This stunning image of the VLT is painted with the colours of sunset and reflected in water on the platform. While inclement weather at Cerro Paranal is unfortunate for the astronomers using it, it lets us see ESO's flagship telescope in a new light. [A. Ghizzi Panizza/ESO]

Planets in the system (twice the size of Earth or bigger), would be detectable with the upgraded instrumentation.
The near- to thermal-infrared range is significant as it corresponds to the heat emitted by a candidate planet, and so enables astronomers to determine whether the planet's temperature allows liquid water. Alpha Centauri is the closest star system to our Solar System, at 4.37 light-years (about 25 trillion miles) away. It consists of two Sun-like stars, Alpha Centauri A and B, plus the red dwarf star, Proxima Centauri.
Current knowledge of Alpha Centauri's planetary systems is sparse. In 2016, a team using ESO instruments discovered one Earth-like planet orbiting Proxima Centauri. But Alpha Centauri A and B remain unknown quantities; it is not clear how stable such binary star systems are for Earth-like planets, and the most promising way to establish whether they exist around these nearby stars is to attempt to observe them.
Imaging such planets, however, is a major technical challenge, since the starlight that reflects off them is generally billions of times dimmer than the light coming to us directly



This image shows NEAR mounted on UT4, with the telescope inclined at low altitude. [ESO/NEAR Collaboration]

from their host stars; resolving a small planet close to its star at a distance of several light-years has been compared to spotting a moth circling a street lamp dozens of miles away. To solve this problem, in 2016 Breakthrough Watch and ESO launched a collaboration to build a special instrument called a thermal infrared coronagraph, designed to block out most of the light coming from the star and optimised to capture the infrared light emitted by the warm surface of an orbiting planet, rather than the small amount of starlight it reflects. Just as objects near to the Sun (normally hidden by its glare) can be seen during a total eclipse, so the coronagraph creates a kind of artificial eclipse of its target star, blocking its light and allowing much dimmer objects in its vicinity to be detected. This marks a significant advance in observational capabilities.

The coronagraph has been installed on one of the VLT's four 8-metre-aperture telescopes, upgrading and modifying an existing instrument, called VISIR, to optimise its sensitiv-

This image shows the NEAR experiment being mounted on the Cassegrain focus of the VLT's UT4. [ESO/NEAR Collaboration]

ity to infrared wavelengths associated with potentially habitable exoplanets. It will therefore be able to search for heat signatures similar to that of the Earth, which absorbs energy from the Sun and emits it in the thermal infrared wavelength range. NEAR modifies the existing VISIR instrument in three ways, combining several cutting-edge astronomical engineering achievements. First, it adapts the instrument for coronagraphy, enabling it to drastically reduce the light of the target star and thereby reveal the signatures of potential terrestrial planets. Second, it uses a technique called adaptive optics to strategically deform the telescope's secondary mirror, compensating for the blur produced by the Earth's atmosphere. Third, it employs novel chopping strategies that also reduce noise, as well as potentially allowing the instrument to switch rapidly between target stars -— as fast as every 100 milliseconds — maximising the available telescope time.

This image shows new hardware being mounted on top of VISIR's cryostat. [ESO/NEAR Collaboration]

Pete Worden, Executive Director of the Breakthrough Initiatives, said: *"We're delighted to collaborate with the ESO in designing, building, installing and now using this innovative new instrument. If there are Earth-like planets around Alpha Centauri A and B, that's huge news for everyone on our planet."*

"ESO is glad to bring its expertise, existing infrastructure, and observing time on the Very Large Telescope to the NEAR project," commented ESO project manager Robin Arsenault.

"This is a valuable opportunity, as — in addition to its own science goals — the NEAR experiment is also a pathfinder for future planet-hunting instruments for the upcoming Extremely Large Telescope," says Markus Kasper, ESO's lead scientist for NEAR.

"NEAR is the first and (currently) only project that could directly image a habitable exoplanet. It marks an important milestone. Fingers crossed — we are hoping a large habitable planet is orbiting Alpha Cen A or B" commented Olivier Guyon, lead scientist for Breakthrough Watch.

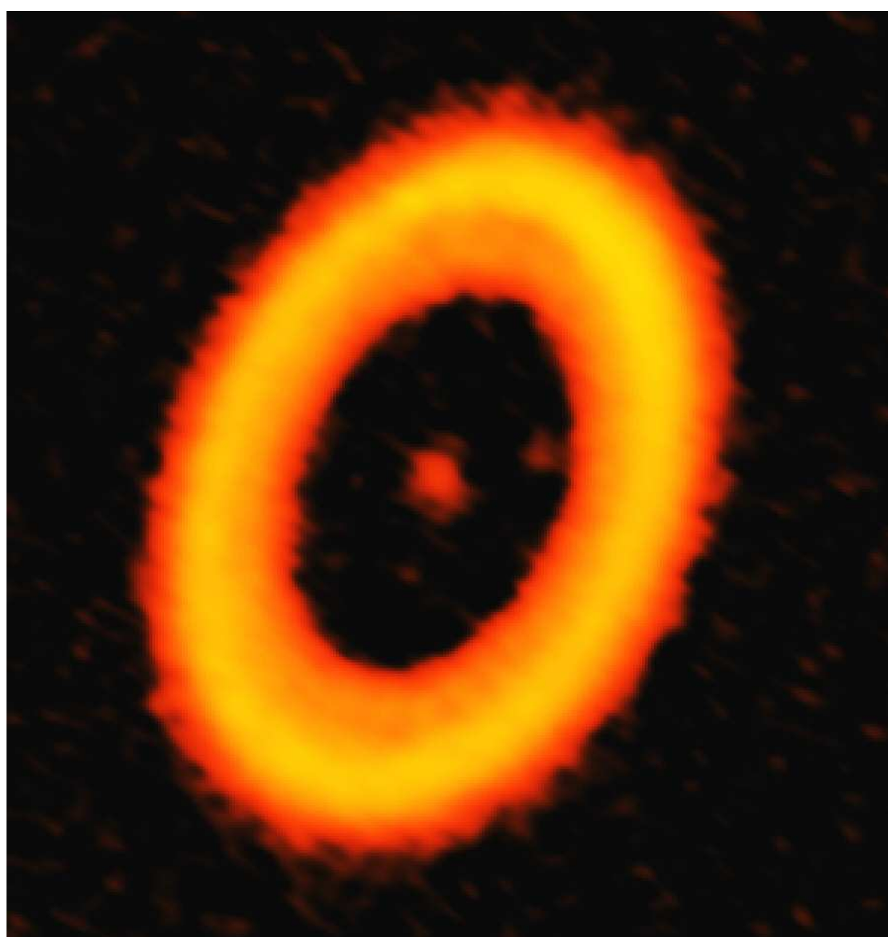
"Human beings are natural explorers," said Yuri Milner, founder of the Breakthrough Initiatives, *"It is time we found out what lies beyond the next valley. This telescope will let us gaze across."*

“Moon forming” circumplanetary disk in a distant star system

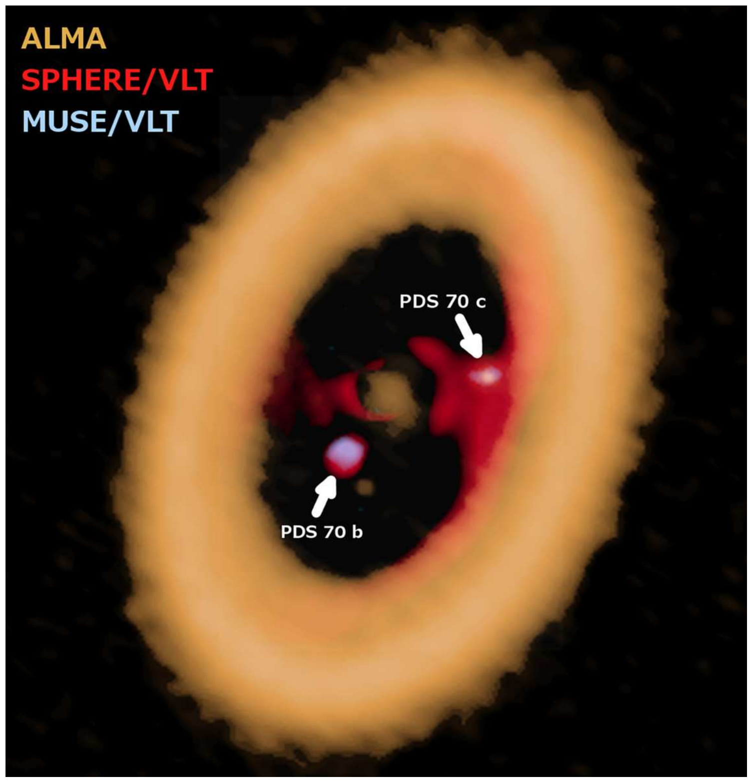
by ALMA Observatory

Astronomers using the Atacama Large Millimeter/submillimeter Array (ALMA) have made the first-ever observations of a circumplanetary disk, the planet-girding belt of dust and gas that astronomers strongly theorize controls the formation of planets and gives rise to an entire system of moons, like the one found around Jupiter. This young star system, PDS 70, is located approximately 370 light-years from Earth. Recently, astronomers confirmed the presence of two massive, Jupiter-like planets in orbit around the star.

This discovery was made with the European Southern Observatory’s Very Large Telescope (VLT), which detected the warm glow natu-



ALMA image of the dust in PDS 70, a star system located approximately 370 light-years from Earth. Two faint smudges in the gap region of this disk are associated with newly formed planets. One such concentration of dust is a circumplanetary disk, the first such feature ever detected around a distant star. [ALMA (ESO/NAOJ/NRAO); A. Isella]



Composite image of PDS 70. Comparing new ALMA data to earlier VLT observations, astronomers determined that the young planet designated PDS 70 c has a circumplanetary disk, a feature that is strongly theorized to be the birthplace of moons. [ALMA (ESO/NOAJ/NRAO) A. Isella; ESO]

rally emitted by hydrogen gas accreting onto the planets. The new ALMA observations instead image the faint radio waves given off by the tiny (about one-tenth of a millimeter across) particles of dust around the star.

The ALMA data, combined with the earlier optical and infrared VLT observations, provide compelling evidence that a dusty disk capable of forming multiple moons surrounds the outermost known planet in the system.

"For the first time, we can conclusively see the telltale signs of a circumplanetary disk, which helps to support many of the current theories of planet formation," said Andrea Isella, an astronomer at Rice University in Houston, Texas, and lead author on a paper published in *The Astrophysical Journal Letters*.

"By comparing our observations to the high-resolution infrared and optical images, we can see that an otherwise enigmatic concentration of tiny dust particles is a planet-girding disk of dust, the first such feature ever conclusively observed," Isella said. According to the researchers, this is the first time that a planet has been seen in these three distinct bands of light (optical, infrared, and radio).

Unlike the icy rings of Saturn, which likely formed by the crashing together of comets and rocky bodies relatively recently in the history of our Solar System, a circumplanetary disk is the lingering remains of the planet-formation process.

The ALMA data also revealed two distinct differences between the two newly discovered planets. The closer in of the two, PDS 70 b, which is about the same distance from its star as Uranus is from the Sun, has a trailing mass of dust behind it resembling a tail. *"What this is and what it means for this planetary system is not yet known,"* said Isella. *"The only conclusive thing we can say is that the tail is far enough from the planet to be an independent feature."*

The second planet, PDS 70 c, resides in the same location as a clear knot of dust seen in the ALMA data. Since this planet is shining so brightly in the infrared and hydrogen bands of light, the astronomers can convincingly say that a fully formed planet is already in orbit there and that nearby gas continues to be siphoned onto the planet's surface, finishing its adolescent growth spurt. This outer planet is located approximately 5.3 billion kilometers from the host star, about the same distance as Neptune from our Sun. Astronomers estimate that this planet is approximately 1 to 10 times the mass of Jupiter. *"If the planet is on the larger end of that estimate, it's quite possible there might be planet-size moons forming around it,"* noted Isella.

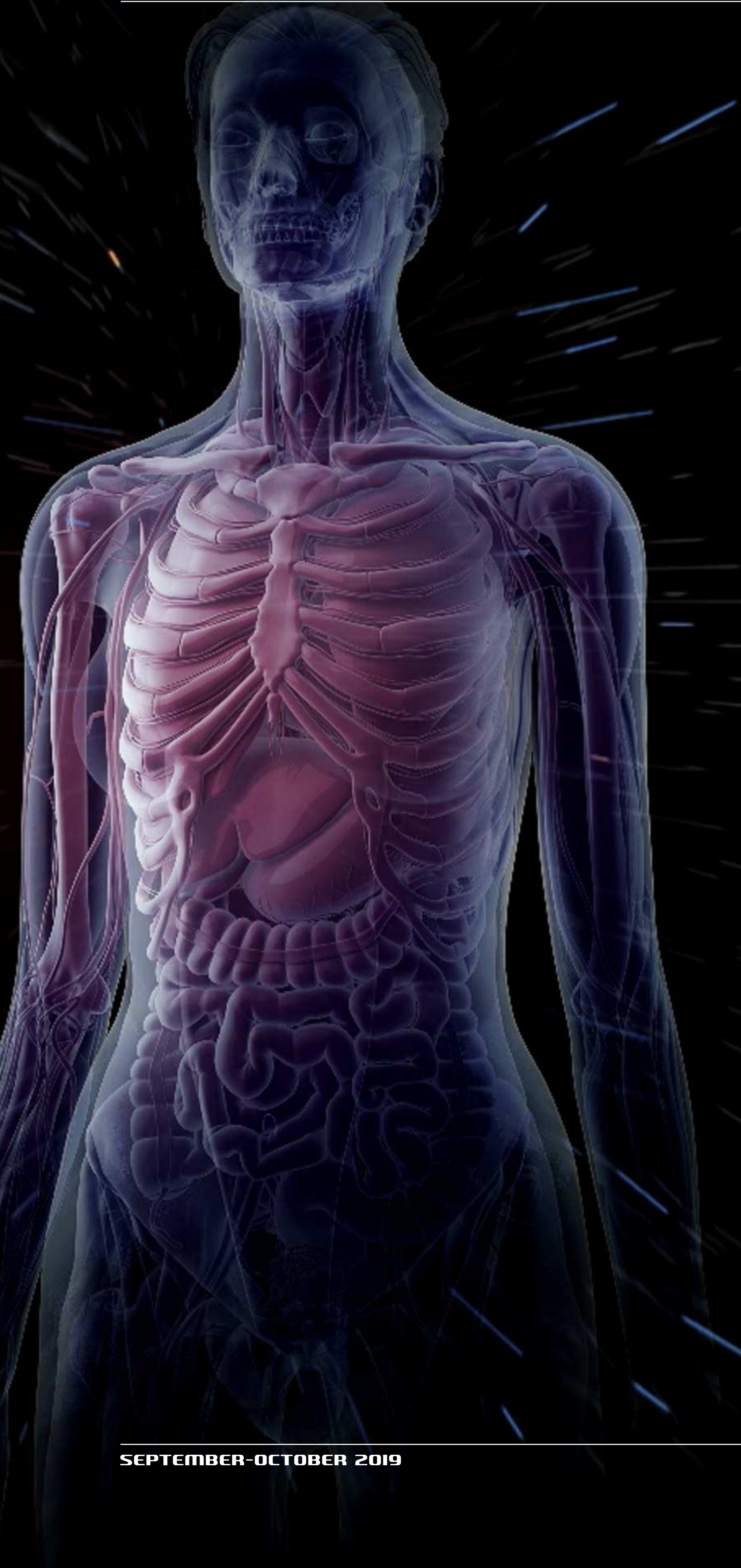
The ALMA observations also add another important element to these conclusions. Optical studies of planetary systems are notoriously challenging. Since the star is so much brighter than the planets, it is difficult to filter out the glare, much like trying to spot a firefly next to a searchlight. ALMA observations, however, don't have that limitation since stars emit comparatively little light at millimeter and submillimeter wavelengths. *"This means we'll be able to come back to this system at different periods and more easily map the orbit of the planets and the concentration of dust in the system,"* concluded Isella. *"This will give us unique insights into the orbital properties of solar systems in their very earliest stages of development."* ■

Space radiation – a deadly obstacle

by Michele Ferrara

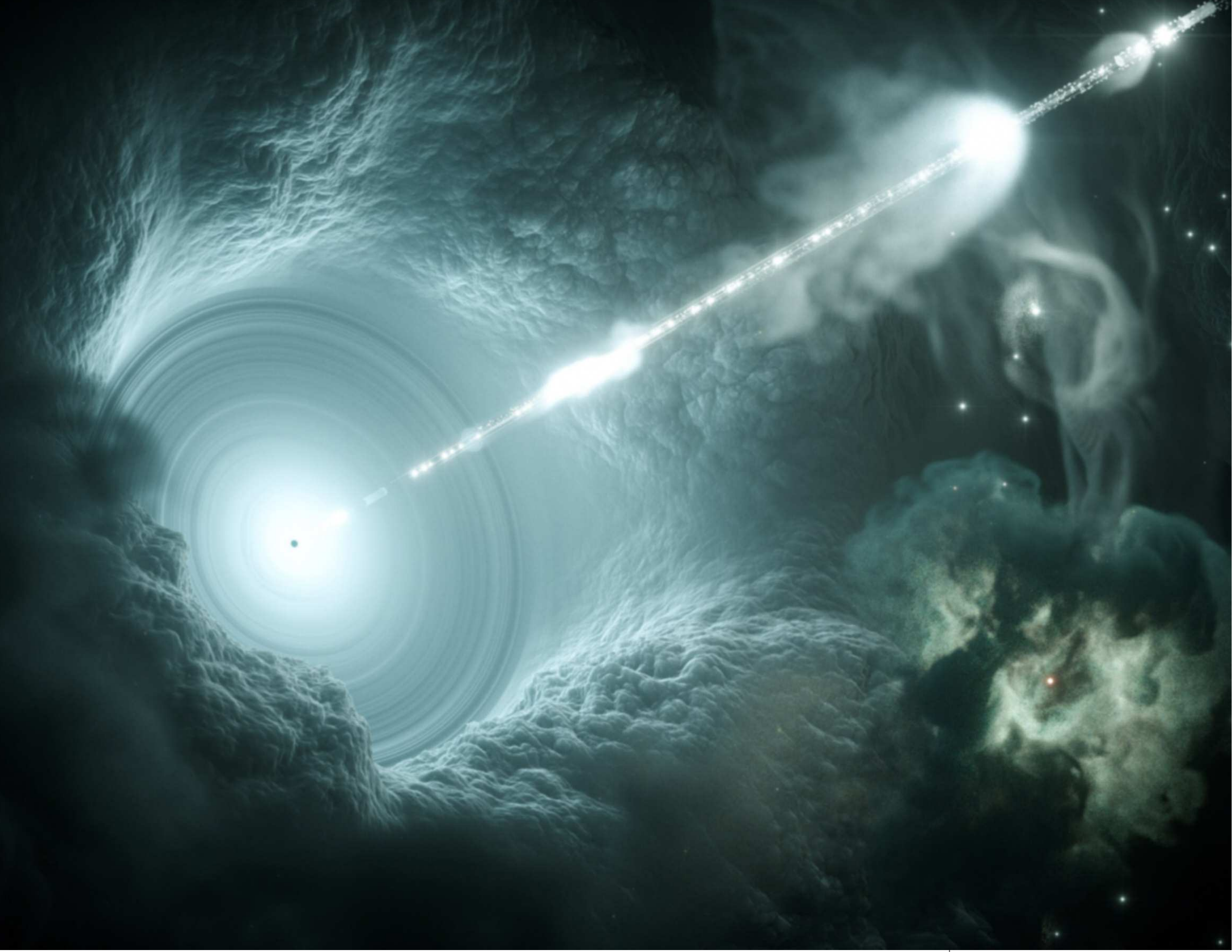
revised by Damian G. Allis
NASA Solar System Ambassador

Research on space radiation has expanded rapidly in recent years, but many uncertainties remain in predicting the biological responses of humans to radiation exposure. Future manned space missions will travel far beyond low Earth orbit and away from the protection of the Earth's magnetosphere, where astronauts will be exposed for long periods to levels of radiation never before experienced. What are the risks to their health?



Today, we have the technological knowledge necessary to make long journeys within the inner Solar System. We could return to the Moon or travel to Mars simply by using what we have already designed. That said, there is a worrying unknown that prevents us from doing so airily, and we are not referring to the availability of adequate funding that we take for granted here. We refer instead to our incomplete knowledge of the effects that space radiation can have on the bodies of astronauts engaged for weeks, months or even years in interplanetary space or on the lunar or Martian surfaces.
Although almost sixty years have passed since the launch of the first man into orbit, and in spite of significant research into the possible pathologies attributable to space radiation, our understanding of the risks space entails for astronauts who remain there for a long time is still very limited and a matter of discussion. In particular, there are significant disparities between basic research results and observed empirical effects seen in astronauts exposed to non-negligible periods of space radiation. This is mainly due to various factors that limit the simulations in terrestrial environments compared to the complex and rapidly changing space weather, as well as the limited extrapolation of studies to human beings based on models developed for animals. For several reasons, these animal models do not faithfully represent the actual human space radiation operating environment, and they even less (or not at all) represent the complexity of human physiology. Specifically, models developed for a variety of animal species with different sensitivities and radiation responses may not be representative of human responses to exposures of equal intensity. Moreover, experimental models are based on historical epidemiological studies that include extreme cases of radiation exposure, such as

Space radiation consists of not only photons, but protons and many of the elements of the periodic table. They enter the human body at energies that can approach the speed of light and can damage DNA. [NASA]



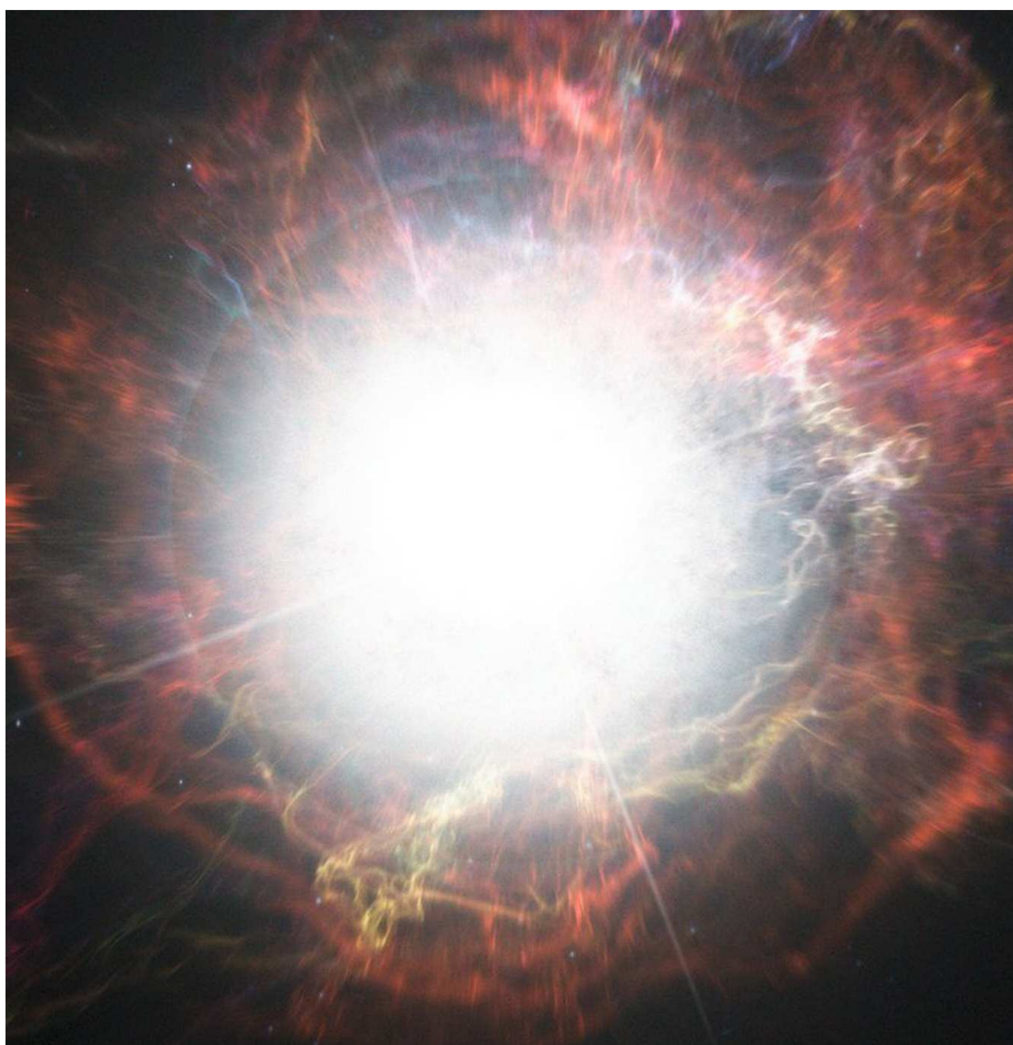
survivors of nuclear power plant accidents and atomic bombing. These forms of total body radiation at high dosages for short periods are not those typical for space flights. The same thing can be said for animal experiments, where, to simulate a series of radiation exposures that astronauts undergo in their careers, subjects are usually exposed to single flows of greater overall intensity and much lower duration. Add to this the fact that studies of the possible effects of space radiation on astronauts usually do not take into consideration the complex energy spectra and diverse ionic composition of the space radiation environment, but are limited instead to assessing exposure to mono-energetic beams composed of restricted types of particles or even of just a single type. In contrast, space missions are faced with a heterogeneous zoo of particles, all with very different energy levels.

There are different types of lethal radiation sources within a typical galaxy: from the occasionally active galactic nucleus (illustration above) to the much more modest but frequent superficial eruptions of stars (video on the side). Whatever the source, radiation always has a deleterious effect on any known lifeform that is more-or-less directly exposed to its flow. [NASA]

Supernovae, like the one depicted below, are the main sources of galactic radiation that enter our Solar System and directly affect the spacecrafts that travel beyond the magnetosphere. [ESO/M. Kornmesser]

All of these experimental inconsistencies and various other environmental considerations give uncertainty to the results of space radiobiology studies, making them only partially usable for extrapolating and predicting the clinical consequences for astronauts. This is not encouraging, as health risks associated with exposure to space radiation will become even more relevant when future manned missions require transfers far beyond low Earth orbit and well beyond the protection of our magnetosphere. So far, only 27 astronauts have exceeded these limits – all during the Apollo program – and have done so only for a few days, a statistically negligible sample for providing meaningful information about the effects of space radiation on the human body. About 530 astronauts have operated in low Earth orbit for extended periods, where only long and/or repeated stays can be considered risky (50 astronauts have exceeded 330 days aboard space stations).

Despite the protection offered by the magnetosphere, an astronaut in orbit accumulates about 200 times more radiation than an airline pilot or a nurse in a radiology unit. On a mission to Mars, astronauts would be subjected to a dose of radiation 700 times



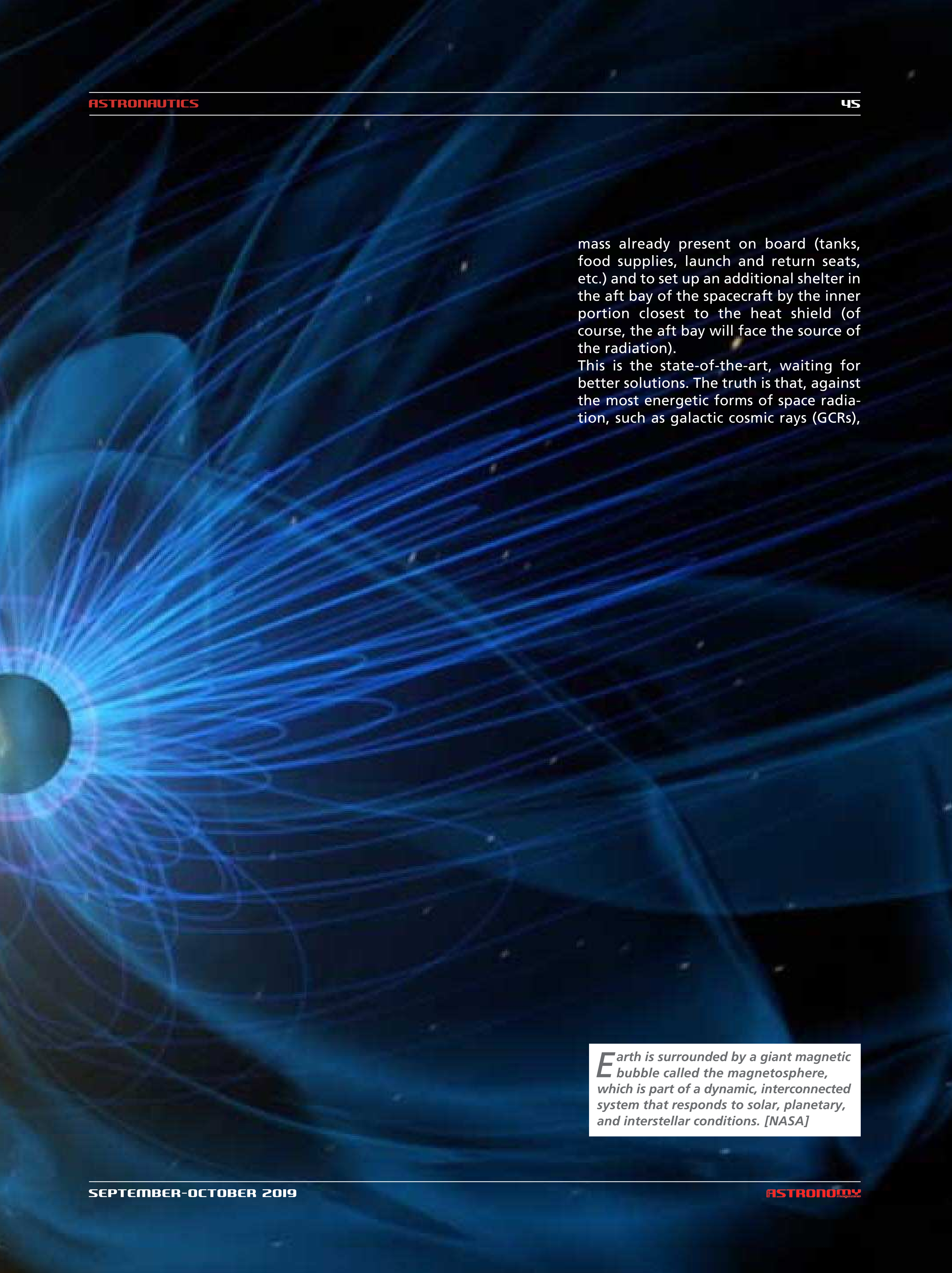
higher than that absorbed in the same period on our planet. During the journey to Mars, assuming about 6 months long, astronauts could be exposed to at least 60% of the total radiation dose limit recommended by space agencies for their entire careers. Adding to the journey to Mars both the stay on the planet and the return journey (almost 2 years in all), an astronaut would have the certainty of being exposed to enough radiation to probably cause serious or even lethal diseases.

This problem could conceivably be solved by reinforcing the shielding of spacecrafts, but this is not feasible, as current spacecrafts already possess shields at the limit of mass compatible with the power of the available carriers. Take, for example, NASA's Orion, the most technologically advanced spacecraft in existence today, currently at an advanced stage of testing and designed for both short missions (nearby asteroids and the Moon) and journeys to Mars. In its case, the best solution adopted against particularly intense and unpredictable flows of high-energy charged particles (typically of solar origin) is to protect the crew by using the

When a high-energy particle hits the Earth's atmosphere, it can produce a cascade of secondary particles of lower energy, as shown above. This phenomenon, called spallation, occurs in a similar way when a charged particle hits a spacecraft hull, generating a flow of intravehicular particles, whose potential effect on the astronauts' bodies is almost unpredictable. [A. Chantelauze, S. Staffi, and L. Bret]

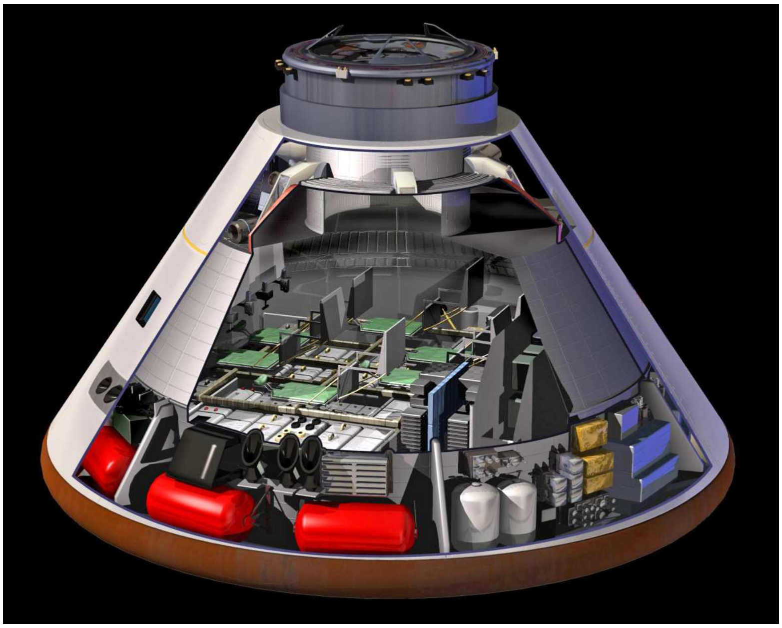
mass already present on board (tanks, food supplies, launch and return seats, etc.) and to set up an additional shelter in the aft bay of the spacecraft by the inner portion closest to the heat shield (of course, the aft bay will face the source of the radiation).

This is the state-of-the-art, waiting for better solutions. The truth is that, against the most energetic forms of space radiation, such as galactic cosmic rays (GCRs),



Earth is surrounded by a giant magnetic bubble called the magnetosphere, which is part of a dynamic, interconnected system that responds to solar, planetary, and interstellar conditions. [NASA]

we can do nothing. GCRs generally originate at a great distance from the Solar System during very violent phenomena, such as stellar explosions. They are atomic nuclei that move at relativistic speeds and possess enough energy to penetrate any kind of shield that can be made today. The GCR spectrum is a complex combination of ions derived from most atomic species found in the Periodic Table. Nearly 87% of GCRs consist of hydrogen ions (protons), 12% of helium ions (α particles), and the remaining 1-2% of heavier nuclei, from lithium to nickel and even, rarely, beyond.

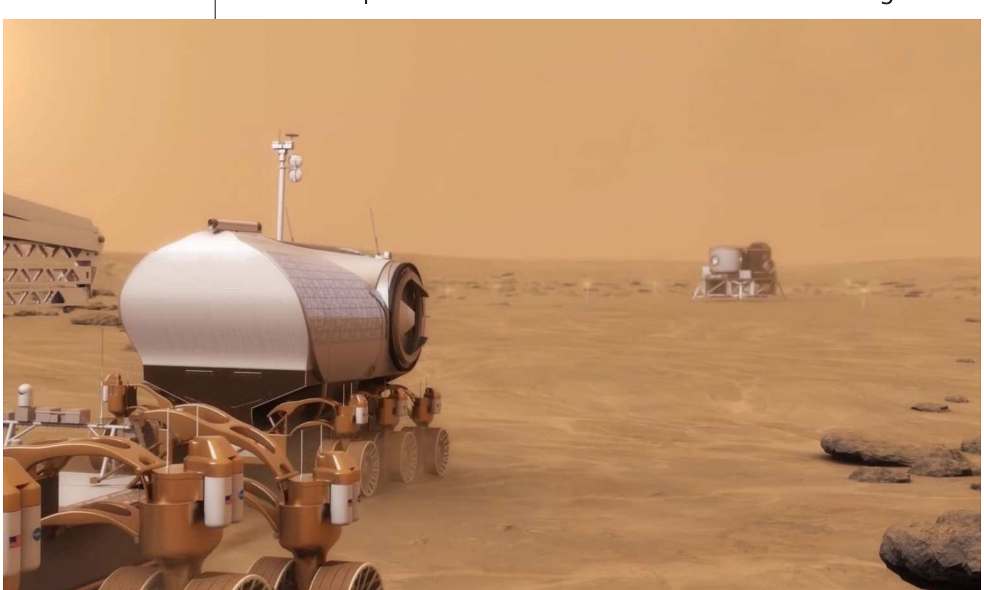


It has been calculated that every cell of an astronaut's body that travels beyond low Earth orbit is crossed by a hydrogen ion every few days. Every few months, the astronaut himself is instead hit by a decidedly heavier ion. Although infrequent, episodes of the last type contribute significantly to the maximum tolerable dose of GCRs. The energies of these heavy ions make them so penetrating that the

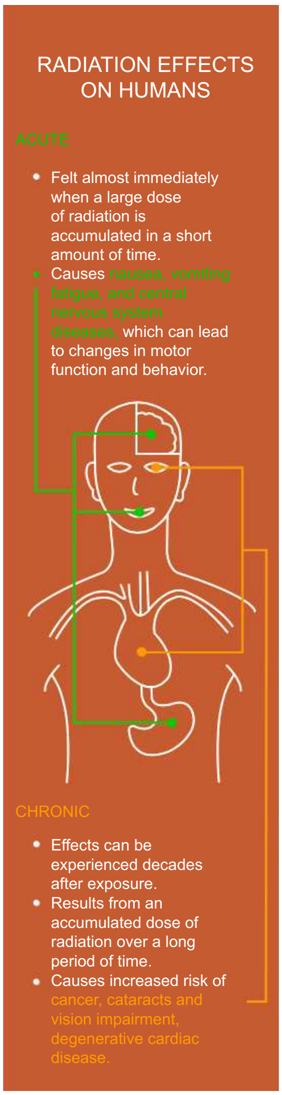
Orion, NASA's new manned spacecraft. The model below shows its interior. Most of the mass transported is concentrated on the bottom and constitutes an additional shield against possible peaks of radiation from the Sun. [NASA]

The human exploration of Mars (illustration below) is partly braked by the impossibility of adequately defending astronauts from space radiation. Recent data from the ExoMars Trace Gas Orbiter (side illustration) showed that during a six-month journey to the red planet an astronaut could be exposed to at least 60% of the total radiation dose limit recommended for their entire career. [NASA, ESA/D. Ducros]

most effective shielding materials can only partially reduce the so-called "intravehicular dose," the flow of particles that invades the cockpit and its inhabitants.



The intravehicular dose is totally unpredictable because the interaction between heavy ions and the spacecraft hull causes the fragmentation of the former into a cascade of lighter secondary particles, whose nature and energy depend on those of the original ion and the targeted material. This process, called "spallation," actually increases the destructive potential of the incoming flow and, depending on the dynamics of the phenomenon and the materials involved, it may turn out that a thicker shield proves more deleterious than a lighter one, leading to the creation of a larger subset of particles. Not knowing the GCR makeup that interacts with a given spacecraft,



we cannot predict the intravehicular radiation spectrum.

This scenario further complicates the work of researchers engaged in modelling space radiation risk.

It can indeed be guessed how the radiation environment of a space flight is unique, complex and unrepeatable in the laboratory. It is the combination of some properties of the particles, such as charge, mass and energy, that determine how quickly they lose energy by interacting with matter.

In the human body, the damage that a given organ receives depends not only on the energy spectrum of the charged particles but also on the depth and density of the tissue mass that lies between the skin surface and the target organ. In general, the heavier the charged particle, the greater the amount of energy deposited per unit path length for that particle. This relationship is referred to as "linear energy transfer" (LET). The high-LET radiation found in the GCR spectrum can produce excessive free radicals that instigate oxidative damage to cell structures. Chronic exposure to such oxidative stress can lead to premature aging, cardiovascular disease and cataract formation.

The precociousness of cataracts in some astronauts is currently the clearest evidence of what is involved in a long stay in space. Although the worst consequences are yet to be demonstrated, the remarkable ionizing power of GCRs makes it a potentially significant contributor to tissue damage, carcinoma onset, central nervous system degeneration and other deleterious pathologies.

More worrisome than GCRs on the effectiveness of the crews in the short term are the so-called "solar particle events" (SPE), which originate from the breaking of lines of force of active regions' magnetic fields present at the surface of the Sun. These real explosions hurl into space short-lasting but very intense flows of ionizing radiation, which, if absorbed by the body of an astronaut in relevant doses, can cause nausea, vomiting, fatigue, weakness, respiratory and digestive diseases, as well as damage to microcirculation. While these effects are mostly latent and do not necessarily entail an immediate risk to the crew's health, they are at the same time more than sufficient to compromise many operations that a long mission requires, as the individual astronauts may not be able to carry out their tasks over the course of an established timeline.

The problems posed by space radiation seem difficult to solve and will undoubtedly further slow down the human exploration of the Moon and Mars. ■

The schematic representation on the left and the video above show the main effects that space radiation can have on the human body during a mission to Mars. [NASA]

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

ESO contributes to protecting Earth from dangerous asteroids

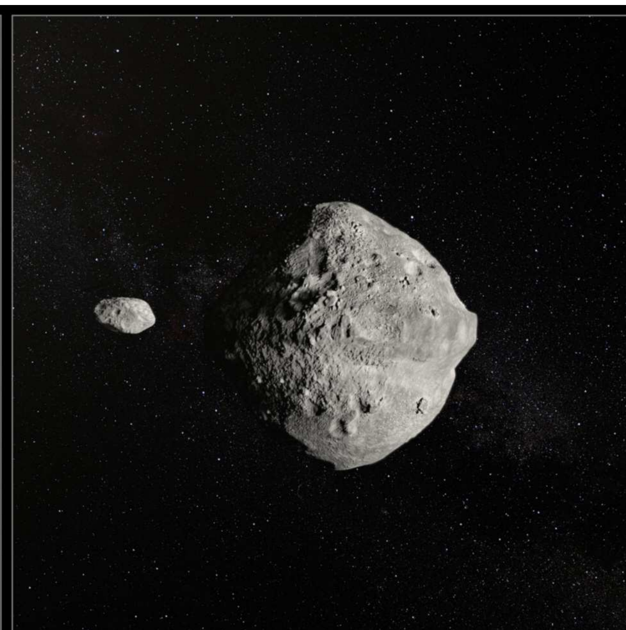
by ESO

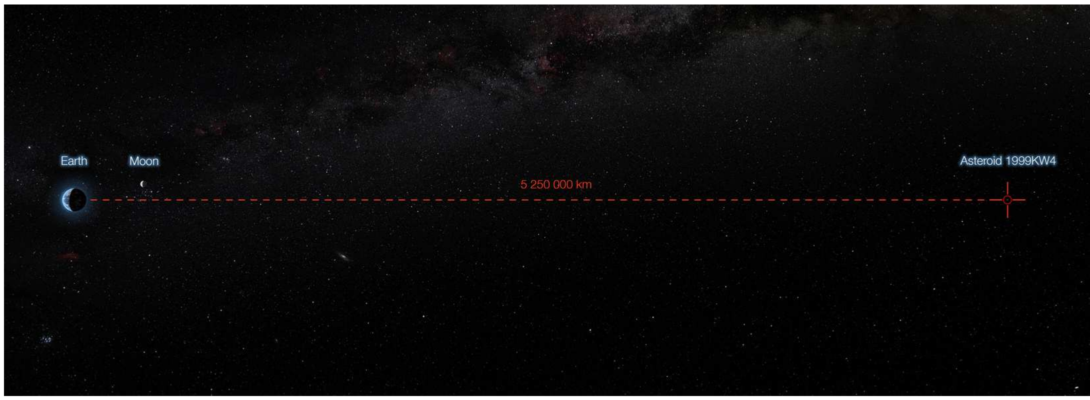
The International Asteroid Warning Network (IAWN) co-ordinated a cross-organisational observing campaign of the asteroid 1999 KW_4 as it flew by Earth, reaching a minimum distance of 5.2 million km on 25 May 2019. 1999 KW_4 is about 1.3 km wide, and does not pose any risk to Earth. Since its orbit is well known, scientists were able to predict this fly-by and prepare the observing campaign.

ESO joined the campaign with its flagship facility, the Very Large Telescope (VLT). The VLT is equipped with SPHERE — one of the very few instruments in the world capable of obtaining images sharp enough to distinguish the two components of the asteroid, which are separated by around 2.6 km.

SPHERE was designed to observe exoplanets; its state-of-the-art adaptive optics (AO) system corrects for the turbulence of the atmosphere, delivering images as sharp as if the telescope were in space. It is also equipped with coronagraphs to dim the glare of bright stars, exposing faint orbiting exoplanets.

The left-hand image shows SPHERE observations of asteroid 1999 KW_4. The angular resolution in this image is equivalent to picking out a single building in New York — from Paris. An artist's impression of the asteroid pair is shown on the right. [ESO]





This infographic shows the minimum distance between the asteroid 1999 KW$_4$ an Earth — the closest the asteroid comes to our planet during its fly-by. [ESO]

Taking a break from its usual night job hunting exoplanets, SPHERE data helped astronomers characterise the double asteroid. In particular, it is now possible to measure whether the smaller satellite has the same composition as the larger object. *"These data, combined with all those that are obtained on other telescopes through the IAWN campaign, will be essential for evaluating effective deflection strategies in the event that an asteroid was found to be on a collision course with Earth,"* explained ESO astronomer Olivier Hainaut. *"In the worst possible case, this knowledge is also essential to predict how an asteroid could interact with the atmosphere and Earth's surface, allowing us to mitigate damage in the event of a collision."*

"The double asteroid was hurtling by the Earth at more than 70 000 km/h, making observing it with the VLT challenging," said Diego Parraguez, who was piloting the telescope. He had to use all his expertise to lock on to the fast asteroid and capture it with SPHERE.

Bin Yang, VLT astronomer, declared *"When we saw the satellite in the AO-corrected images, we were extremely thrilled. At that moment, we felt that all the pain, all the efforts were worth it."*

Mathias Jones, another VLT astronomer involved in these observations, elaborated on the difficulties. *"During the observations the atmospheric conditions were a bit unstable. In addition, the asteroid was relatively faint and moving very fast in the sky, making these observations particularly challenging, and causing the AO system to crash several times. It was great to see our hard work pay off despite the difficulties!"*

This artist's impression shows both components of the double asteroid 1999 KW$_4$ tumbling through space during its Earth fly-by. [ESO/M. Kornmesser]

While 1999 KW$_4$ is not an impact threat, it bears a striking resemblance to another binary asteroid system called Didymos which could pose a threat to Earth sometime in the distant future. Didymos and its companion called "Didymoon" are the target of a future pioneering planetary defence experiment. NASA's DART spacecraft will impact Didymoon in an attempt to change its orbit around its larger twin, in a test of the feasibility of deflecting asteroids.

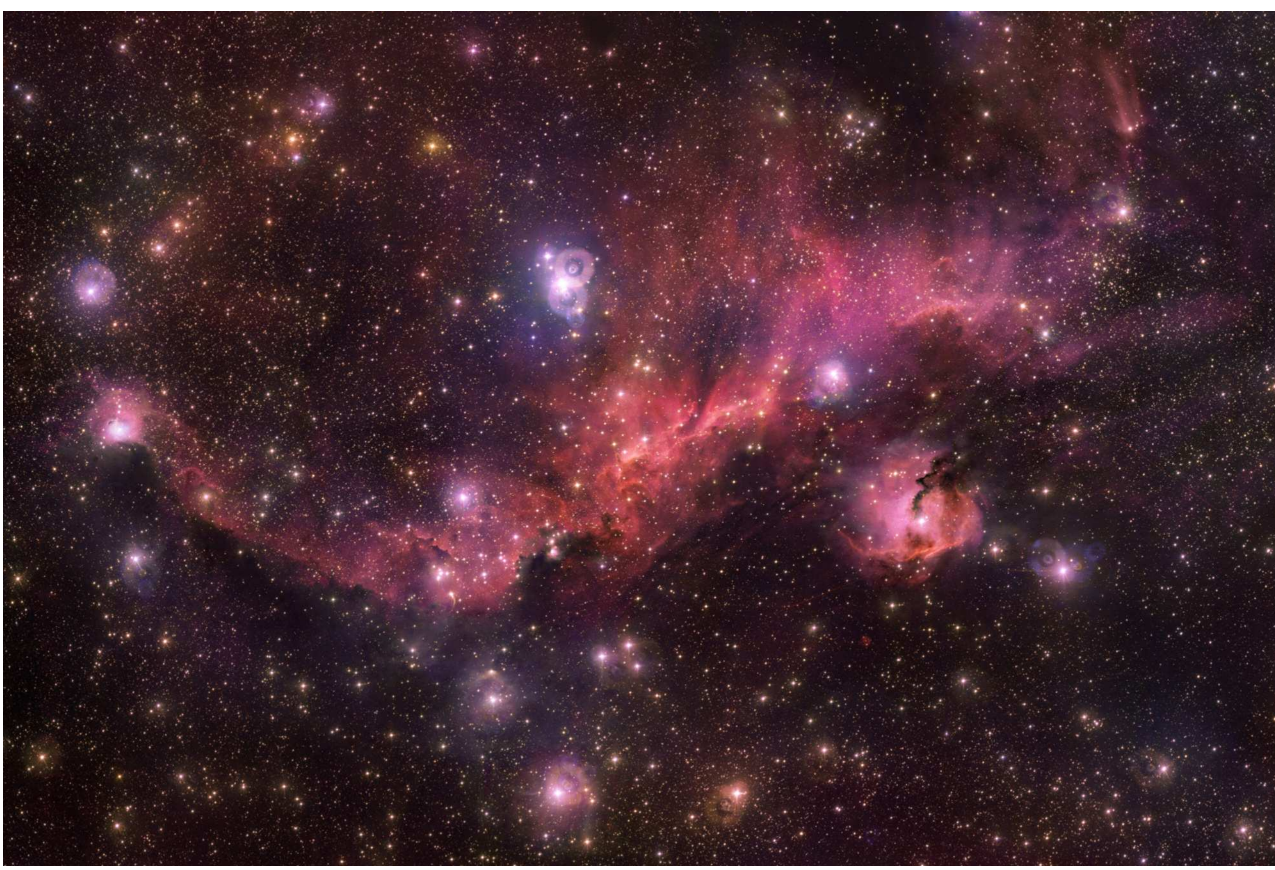
After the impact, ESA's Hera mission will survey the Didymos asteroids in 2026 to gather key information, including Didymoon's mass, its surface properties and the shape of the DART crater. The success of such missions depends on collaborations between organisations, and tracking Near-Earth Objects is a major focus for the collaboration between ESO and ESA.

This cooperative effort has been ongoing since their first successful tracking of a potentially hazardous NEO in early 2014. *"We are delighted to be playing a role in keeping Earth safe from asteroids,"* said Xavier Barcons, ESO's Director General. *"As well as employing the sophisticated capabilities of the VLT, we are working with ESA to create prototypes for a large network to take asteroid detection, tracking and characterization to the next level."*

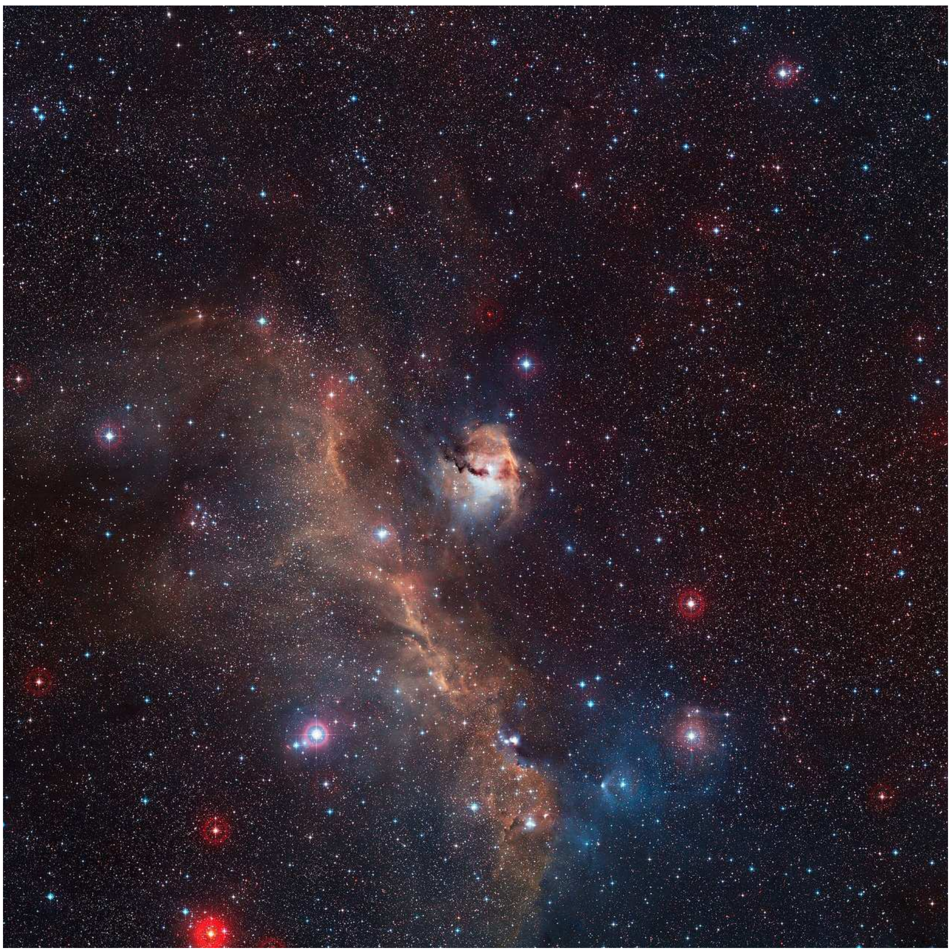
VST captures a celestial gull in flight

by ESO

The main components of the Seagull are three large clouds of gas, the most distinctive being Sharpless 2-296, which forms the "wings". Spanning about 100 light-years from one wingtip to the other, Sh2-296 displays glowing material and dark dust lanes weaving amid bright stars. It is a beautiful example of an emission nebula, in this case an HII region, indicating active formation of new stars, which can be seen peppering this image.
It is the radiation emanating from these young stars that gives the clouds their fantastical colours and makes them so eye-catching, by ionising the surrounding gas and caus-



Colourful and wispy Sharpless 2-296 forms the "wings" of an area of sky known as the Seagull Nebula — named for its resemblance to a gull in flight. This celestial bird contains a fascinating mix of intriguing astronomical objects. Glowing clouds weave amid dark dust lanes and bright stars. The Seagull Nebula — made up of dust, hydrogen, helium and traces of heavier elements — is the hot and energetic birthplace of new stars. [ESO/VPHAS+ team/N.J. Wright (Keele University)]



This wide-field view captures the evocative and colourful star formation region of the Seagull Nebula, IC 2177, on the borders of the constellations of Monoceros (The Unicorn) and Canis Major (The Great Dog). This view was created from images forming part of the Digitized Sky Survey 2. [ESO/Digitized Sky Survey 2]

ing it to glow. This radiation is also the main factor that determines the clouds' shapes, by exerting pressure on the surrounding material and sculpting it into the whimsical morphologies we see. Since each nebula has a unique distribution of stars and may, like this one, be a composite of multiple clouds, they come in a variety of shapes, firing astronomers' imaginations and evoking comparisons to animals or familiar objects. This diversity of shapes is exemplified by the contrast between Sh2-296 and Sh2-292. The latter, seen here just below the "wings", is a more compact cloud that forms the seagull's "head". Its most prominent feature is a huge, extremely luminous star called HD 53367 that is 20 times more massive than the Sun, and which we see as the seagull's piercing "eye". Sh2-292 is both an emission nebula and a reflection nebula; much of its light is emitted by ionised gas surrounding its nascent stars, but a significant amount is also reflected from stars outside it.

The dark swathes that interrupt the clouds' homogeneity and give them texture are dust lanes – paths of much denser material that hide some of the luminous gas behind them. Nebulae like this one have densities of a few hundred atoms per cubic centimetre, much less than the best artificial vacuums on Earth. Nonetheless, nebulae are still much denser than the gas outside them, which has an average density of about 1 atom per cubic centimetre.

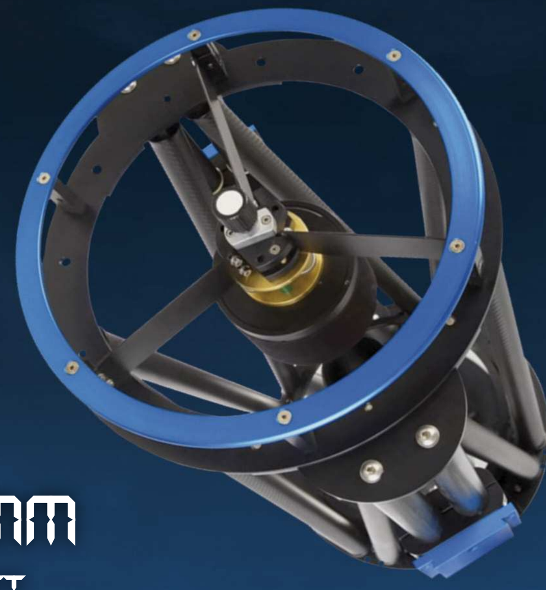
The Seagull lies along the border between the constellations of Canis Major (The Great Dog) and Monoceros (The Unicorn), at a distance of about 3700 light-years in one arm of the Milky Way. Spiral galaxies can contain thousands of these clouds, almost all of which are concentrated along their whirling arms.

Several smaller clouds are also counted as part of the Seagull Nebula, including Sh2-297, which is a small, knotty addition to the tip of the gull's upper "wing", Sh2-292 and Sh2-295. These objects are all included in the Sharpless Catalogue, a list of over 300 clouds of glowing gas compiled by American astronomer Stewart Sharpless.

This image was taken using the VLT Survey Telescope (VST), one of the largest survey telescopes in the world observing the sky in visible light. The VST is designed to photograph large areas of the sky quickly and deeply. Can you spot the seagull in this photo? We challenge our readers to let their imagination run free and outline the bird in our photo as they see it. Share your photos with the outline of the bird using the hashtag #SpotTheSeagull. ■

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