South Downs Mercury

The monthly circular of South Downs Astronomical Society
Issue: 555 – August 2021 Editor: Roger Burgess

Hopefully we will be holding the delayed AGM on the 3rd September with a speaker, we are looking for a new secretary and committee members, so you have time to prepare. Further details will be in the September Newsletter

- Anatomy of the red planet: Mars-quakes reveal interior

Date: July 22, 2021
Source: ETH Zurich

Planet Mars (stock image; elements furnished by NASA).
Credit: © Artsiom P / stock.adobe.com

Since early 2019, researchers have been recording and analysing marsquakes as part of the InSight mission. This relies on a seismometer whose data acquisition and control electronics were developed at ETH Zurich. Using this data, the researchers have now measured the red planet's crust, mantle and core -- data that will help determine the formation and evolution of Mars and, by extension, the entire solar system.

Mars once completely molten

We know that Earth is made up of shells: a thin crust of light, solid rock surrounds a thick mantle of heavy, viscous rock, which in turn envelopes a core consisting mainly of iron and nickel. Terrestrial planets, including Mars, have been assumed to have a similar structure. "Now seismic data has confirmed that Mars presumably was once completely molten before dividing into the crust, mantle and core we see today, but that these are different from Earth's," says Amir Khan, a scientist at the Institute of Geophysics at ETH Zurich and at the Physics Institute at the University of Zurich. Together with his ETH colleague Simon Stähler, he analysed data from NASA's InSight mission, in which ETH Zurich is participating under the leadership of Professor Domenico Giardini.

No plate tectonics on Mars

The researchers have discovered that the Martian crust under the probe's landing site near the Martian equator is between 15 and 47 kilometres thick. Such a thin crust must contain a relatively high proportion of radioactive elements, which calls into question previous models of the chemical composition of the entire crust.

Beneath the crust comes the mantle with the lithosphere of more solid rock reaching 400-600 kilometres down -- twice as deep as on Earth. This could be because there is now only one continental plate on Mars, in contrast to Earth with its seven large mobile plates. "The thick lithosphere fits well with the model of Mars as a 'one-plate planet'," Khan concludes.

The measurements also show that the Martian mantle is mineralogically similar to Earth's upper mantle. "In that sense, the Martian mantle is a simpler version of Earth's mantle." But the seismology also reveals differences in chemical composition. The Martian mantle, for example, contains more iron than Earth's. However, theories as to the complexity of the layering of the Martian mantle also depend on the size of the underlying core -- and here, too, the researchers have come to new conclusions.

The core is liquid and larger than expected

The Martian core has a radius of about 1,840 kilometres, making it a good 200 kilometres larger than had been assumed 15 years ago, when the InSight mission was planned. The

researchers were now able to recalculate the size of the core using seismic waves. "Having determined the radius of the core, we can now calculate its density," Stähler says.
"If the core radius is large, the density of the core must be relatively low," he explains: "That means the core must contain a large proportion of lighter elements in addition to iron and nickel." These include sulphur, oxygen, carbon and hydrogen, and make up an unexpectedly large proportion. The researchers conclude that the composition of the entire planet is not yet fully understood. Nonetheless, the current investigations confirm that the core is liquid -- as suspected -- even if Mars no longer has a magnetic field.

Reaching the goal with different waveforms

The researchers obtained the new results by analysing various seismic waves generated by marsquakes. "We could already see different waves in the InSight data, so we knew how far away from the lander these quake epicentres were on Mars," Giardini says. To be able to say something about a planet's inner structure calls for quake waves that are reflected at or below the surface or at the core. Now, for the first time, researchers have succeeded in observing and analysing such waves on Mars.
"The InSight mission was a unique opportunity to capture this data," Giardini says. The data stream will end in a year when the lander's solar cells are no longer able to produce enough power. "But we're far from finished analysing all the data -- Mars still presents us with many mysteries, most notably whether it formed at the same time and from the same material as our Earth." It is especially important to understand how the internal dynamics of Mars led it to lose its active magnetic field and all surface water. "This will give us an idea of whether and how these processes might be occurring on our planet," Giardini explains. "That's our reason why we are on Mars, to study its anatomy."

- Scientists observe gas re-accretion in dying galaxies for the first time

Date: July 29, 2021
Source: National Radio Astronomy Observatory

A new study from scientists using the Atacama Large Millimetre/submillimetre Array (ALMA) suggests that previously displaced gases can re-accrete onto galaxies, potentially slowing down the process of galaxy death caused by ram pressure stripping, and creating unique structures more resistant to its effects.
"Much of the previous work on ram pressure stripped galaxies is focused on the material that gets stripped out of galaxies. In this new work we see some gas that rather than being thrown out of the galaxy never to return is instead moving like a boomerang, being ejected out but then circling around and falling back to its source," said William Cramer, an astronomer at Arizona State University and the lead author on the new study. "By combining Hubble and ALMA data at very high resolution, we are able to prove that this process is happening."
Ram pressure stripping refers to the process that displaces gas from galaxies, leaving them without the material needed to form new stars. As galaxies move through their galaxy clusters, hot gas known as the intra-cluster medium -- or, the space between -- acts like a forceful wind, pushing gases out of the traveling galaxies. Over time, this leads to the starvation and "death" of once-active star-forming galaxies. Because ram pressure stripping can speed up the normal life cycle of galaxies and alter the amount of molecular gas within them, it is of particular interest to scientists studying the life, maturation, and death of galaxies.
"We've seen in simulations that not all of the gas being pushed by ram pressure stripping escapes the galaxy because it has to reach escape velocity in order to actually escape and not fall back. The re-accretion that we're

seeing, we believe is from clouds of gas that were pushed out of the galaxy by ram pressure stripping, and didn't achieve escape velocity, so they're falling back," said Jeff Kenney, an astronomer at Yale University, and the co-author on the study. "If you're trying to predict how fast a galaxy is going to stop forming stars over time and transform into a red, or dead galaxy, then you want to understand how effective ram pressure is at stripping the gas out. If you don't know that gas can fall back onto the galaxy and continue to recycle and form new stars, you're going to overpredict the quenching of the stars. Having proof of this process means more accurate timelines for the lifecycle of galaxies."

The new study focuses on NGC 4921 -- a barred spiral galaxy and the largest spiral galaxy in the Coma Cluster -- located roughly 320 million light-years from Earth in the constellation Coma Berenices. NGC 4921 is of particular interest to scientists studying the effects of ram pressure stripping because evidence of both the process and its aftermath is abundant.

"Ram pressure triggers star formation on the side where it is having the greatest impact on the galaxy," said Cramer. "It's easy to identify in NGC 4921 because there are many young blue stars on the side of the galaxy where it's occurring."

Kenney added that ram pressure stripping in NGC 4921 has created a strong, visible line between where dust still exists in the galaxy and where it doesn't. "There is a strong dust line present, and beyond that there's almost no gas in the galaxy. We think that that part of the galaxy has been almost completely cleaned out by ram pressure."

Using ALMA's Band 6 receiver, scientists were able to resolve carbon monoxide, the key to "seeing" both those areas of the galaxy devoid of gas, as well as those areas where it is re-accreting. "We know that the majority of molecular gas in galaxies is in the form of hydrogen, but molecular hydrogen is very difficult to observe directly," said Cramer. "Carbon monoxide is commonly used as a proxy for studying molecular gas in galaxies because it is much easier to observe."

The ability to see more of the galaxy, even at its faintest, unveiled interesting structures likely created in the process of gas displacement, and further immune to its effects. "Ram pressure appears to form unique structures, or filaments in galaxies that are clues as to how a galaxy evolves under a ram pressure wind. In the case of NGC 4921, they bear a striking resemblance to the famous nebula, the Pillars of Creation, although on a much more massive scale," said Cramer. "We think that they are supported by magnetic fields which are preventing them from being stripped away with the rest of the gas."

Observations revealed that the structures are more than just wisps of gas and dust; the filaments have mass and a lot of it. "These filaments are heavier and stickier -- they hold on to their material more tightly than the rest of the galaxy's interstellar medium can do -- and they seem to be connected to that big dust ridge both in space and in velocity," said Kenney. "They're more like molasses than smoke. If you just blow on something that is smoke, the smoke is light, and it disperses and goes in all directions. But this is much heavier than that."

Although a significant breakthrough, the results of the study are only a starting point for Cramer and Kenney, who examined one small part of just one galaxy. "If we want to predict the death rate of galaxies, and the birth rate of new stars, we need to understand if and how much of the material that forms stars, originally lost to ram pressure, is actually recycled back," said Cramer. "These observations are of just one quadrant of NGC 4921. There is likely even more gas falling back into other quadrants. While we have confirmed that some stripped gas can 'rain' back down, we need more observations to quantify how much gas falls back and how many new stars form as a result."

"A fascinating study, demonstrating the power of ALMA and the benefit of combining its observations with those of a telescope at other wavelengths," added Joseph Pesce, NRAO/ALMA program officer at the NSF. "Ram pressure stripping is an important phenomenon for galaxies in clusters, and understanding the process better allows us to understand galaxy evolution -- and nature -- better."

- Hubble finds evidence of water vapor at Jupiter's moon Ganymede

Date: July 26, 2021
Source: Space Telescope Science Institute (STScI)

Illustration of the planet Jupiter and moon Ganymede (stock image).
Credit: © ianm35 / stock.adobe.com

For the first time, astronomers have uncovered evidence of water vapor in the atmosphere of Jupiter's moon Ganymede. This water vapor forms when ice from the moon's surface sublimates -- that is, turns from solid to gas. Scientists used new and archival datasets from NASA's Hubble Space Telescope to make the discovery, published in the journal *Nature Astronomy.*

Previous research has offered circumstantial evidence that Ganymede, the largest moon in the solar system, contains more water than all of Earth's oceans. However, temperatures there are so cold that water on the surface is frozen solid. Ganymede's ocean would reside roughly 100 miles below the crust; therefore, the water vapor would not represent the evaporation of this ocean.

Astronomers re-examined Hubble observations from the last two decades to find this evidence of water vapor.

In 1998, Hubble's Space Telescope Imaging Spectrograph (STIS) took the first ultraviolet (UV) images of Ganymede, which revealed in two images colourful ribbons of electrified gas called auroral bands, and provided further evidence that Ganymede has a weak magnetic field.

The similarities in these UV observations were explained by the presence of molecular oxygen (O_2). But some observed features did not match the expected emissions from a pure O_2 atmosphere. At the same time, scientists concluded this discrepancy was likely related to higher concentrations of atomic oxygen (O).

As part of a large observing program to support NASA's Juno mission in 2018, Lorenz Roth of the KTH Royal Institute of Technology in Stockholm, Sweden led the team that set out to measure the amount of atomic oxygen with Hubble. The team's analysis combined the data from two instruments: Hubble's Cosmic Origins Spectrograph (COS) in 2018 and archival images from the Space Telescope Imaging Spectrograph (STIS) from 1998 to 2010.

To their surprise, and contrary to the original interpretations of the data from 1998, they discovered there was hardly any atomic oxygen in Ganymede's atmosphere. This means there must be another explanation for the apparent differences in these UV aurora images.

Roth and his team then took a closer look at the relative distribution of the aurora in the UV images. Ganymede's surface temperature varies strongly throughout the day, and around noon near the equator it may become sufficiently warm that the ice surface releases (or sublimates) some small amounts of water molecules. In fact, the perceived differences in the UV images are directly correlated with where water would be expected in the moon's atmosphere.

"So far only the molecular oxygen had been observed," explained Roth. "This is produced when charged particles erode the ice surface. The water vapor that we measured now originates from ice sublimation caused by the thermal escape of water vapor from warm icy regions."

This finding adds anticipation to ESA (European Space Agency)'s upcoming mission, JUICE, which stands for JUpiter ICy moons Explorer. JUICE is the first large-class mission in ESA's Cosmic Vision 2015-2025 program. Planned for launch in 2022 and arrival at Jupiter in 2029, it will spend at least three years making detailed observations of Jupiter and three of its largest moons, with particular emphasis on Ganymede as a planetary body and potential habitat.

Ganymede was identified for detailed investigation because it provides a natural laboratory for analysis of the nature, evolution and potential habitability of icy worlds in general, the role it plays within the system of Galilean satellites, and its unique magnetic and plasma interactions with Jupiter and its environment.

"Our results can provide the JUICE instrument teams with valuable information that may be used to refine their observation plans to optimize the use of the spacecraft," added Roth.

Right now, NASA's Juno mission is taking a close look at Ganymede and recently released new imagery of the icy moon. Juno has been

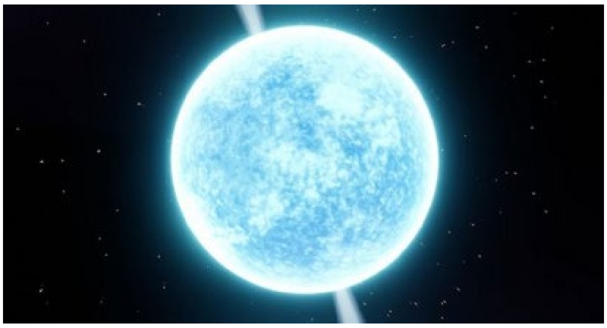
studying Jupiter and its environment, also known as the Jovian system, since 2016. Understanding the Jovian system and unravelling its history, from its origin to the possible emergence of habitable environments, will provide us with a better understanding of how gas giant planets and their satellites form and evolve. In addition, new insights will hopefully be found on the habitability of Jupiter-like exoplanetary systems.
The Hubble Space Telescope is a project of international cooperation between NASA and ESA (European Space Agency). NASA's Goddard Space Flight Centre in Greenbelt, Maryland, manages the telescope. The Space Telescope Science Institute (STScI) in Baltimore, Maryland, conducts Hubble science operations. STScI is operated for NASA by the Association of Universities for Research in Astronomy in Washington, D.C.

- Scientists capture most-detailed radio image of Andromeda galaxy to date

Disk of galaxy identified as region where new stars are born
Date: July 28, 2021
Source: University of British Columbia
Scientists have published a new, detailed radio image of the Andromeda galaxy -- the Milky Way's sister galaxy -- which will allow them to identify and study the regions of Andromeda where new stars are born.
The study -- which is the first to create a radio image of Andromeda at the microwave frequency of 6.6 GHz -- was led by University of British Columbia physicist Sofia Fatigoni, with colleagues at Sapienza University of Rome and the Italian National Institute of Astrophysics. It was published online in *Astronomy and Astrophysics.*
"This image will allow us to study the structure of Andromeda and its content in more detail than has ever been possible," said Fatigoni, a PhD student in the department of physics and astronomy at UBC.
"Understanding the nature of physical processes that take place inside Andromeda allows us to understand what happens in our own galaxy more clearly -- as if we were looking at ourselves from the outside."
Prior to this study, no maps capturing such a large region of the sky around the Andromeda Galaxy had ever been made in the microwave band frequencies between one GHz to 22 GHz. In this range, the galaxy's emission is very faint, making it hard to see its structure. However, it is only in this frequency range that particular features are visible, so having a map at this particular frequency is crucial to understanding which physical processes are happening inside Andromeda.
In order to observe Andromeda at this frequency, the researchers required a single-dish radio telescope with a large effective area. For the study, the scientists turned to the Sardinia Radio Telescope, a 64-metre fully steerable telescope capable of operating at high radio frequencies.
It took 66 hours of observation with the Sardinia Radio Telescope and consistent data analysis for the researchers to map the galaxy with high sensitivity. They were then able to estimate the rate of star formation within Andromeda, and produce a detailed map that highlighted the disk of the galaxy as the region where new stars are born.
"By combining this new image with those previously acquired, we have made significant steps forward in clarifying the nature of Andromeda's microwave emissions and allowing us to distinguish physical processes that occur in different regions of the galaxy," said Dr. Elia Battistelli, a professor in the department of physics at Sapienza and coordinator of the study.
"In particular, we were able to determine the fraction of emissions due to thermal processes related to the early stations of new star formation, and the fraction of radio signals attributable to non-thermal mechanisms due to cosmic rays that spiral in the magnetic field present in the interstellar medium," Fatigoni said.
For the study, the team developed and implemented software that allowed -- among other things -- to test new algorithms to identify never-before-examined lower emission sources in the field of view around Andromeda at a frequency of 6.6 GHz. From the resulting map, researchers were able to identify a catalogue of about 100 point sources, including stars, galaxies and other objects in the background of Andromeda.

- Millimetre-tall 'mountains' on neutron stars

Date: July 18, 2021
Source: Royal Astronomical Society

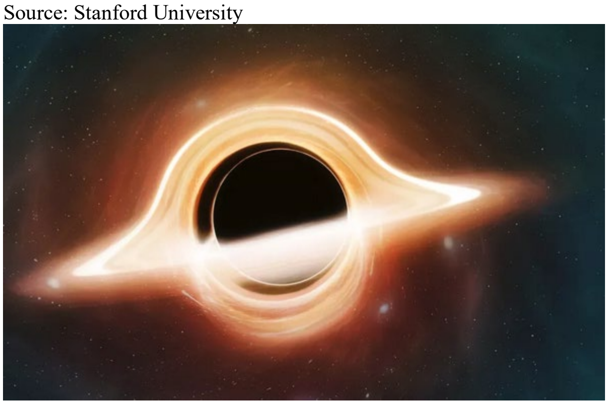


Neutron star illustration (stock image).
Credit: © Artur / stock.adobe.com

New models of neutron stars show that their tallest mountains may be only fractions of millimetres high, due to the huge gravity on the ultra-dense objects. The research is presented today at the National Astronomy Meeting 2021.
Neutron stars are some of the densest objects in the Universe: they weigh about as much as the Sun, yet measure only around 10km across, similar in size to a large city.
Because of their compactness, neutron stars have an enormous gravitational pull around a billion times stronger than the Earth. This squashes every feature on the surface to miniscule dimensions, and means that the stellar remnant is an almost perfect sphere.
Whilst they are billions of times smaller than on Earth, these deformations from a perfect sphere are nevertheless known as mountains.
The team behind the work, led by PhD student Fabian Gittins at the University of Southampton, used computational modelling to build realistic neutron stars and subject them to a range of mathematical forces to identify how the mountains are created.
The team also studied the role of the ultra-dense nuclear matter in supporting the mountains, and found that the largest mountains produced were only a fraction of a millimetre tall, one hundred times smaller than previous estimates.
Fabian comments, "For the past two decades, there has been much interest in understanding how large these mountains can be before the crust of the neutron star breaks, and the mountain can no longer be supported."
Past work has suggested that neutron stars can sustain deviations from a perfect sphere of up to a few parts in one million, implying the mountains could be as large as a few centimetres. These calculations assumed the neutron star was strained in such a way that the crust was close to breaking at every point. However the new models indicate that such conditions are not physically realistic.
Fabian adds: "These results show how neutron stars truly are remarkably spherical objects. Additionally, they suggest that observing gravitational waves from rotating neutron stars may be even more challenging than previously thought."
Although they are single objects, due to their intense gravitation, spinning neutron stars with slight deformations should produce ripples in the fabric of spacetime known as gravitational waves. Gravitational waves from rotations of single neutron stars have yet to be observed, although future advances in extremely sensitive detectors such as advanced LIGO and Virgo may hold the key to probing these unique objects.

- ❖ First detection of light from behind a black hole

Date: July 28, 2021
Source: Stanford University



Watching X-rays flung out into the universe by the supermassive black hole at the centre of a galaxy 800 million light-years away, Stanford University astrophysicist Dan Wilkins noticed an intriguing pattern. He observed a series of bright flares of X-rays -- exciting, but not unprecedented -- and then, the telescopes recorded something unexpected: additional flashes of X-rays that were smaller, later and of different "colours" than the bright flares.
According to theory, these luminous echoes were consistent with X-rays reflected from behind the black hole -- but even a basic understanding of black holes tells us that is a strange place for light to come from.
"Any light that goes into that black hole doesn't come out, so we shouldn't be able to see anything that's behind the black hole," said Wilkins, who is a research scientist at the Kavli Institute for Particle Astrophysics and Cosmology at Stanford and SLAC National Accelerator Laboratory. It is another strange characteristic of the black hole, however, that makes this observation possible. "The reason

we can see that is because that black hole is warping space, bending light and twisting magnetic fields around itself," Wilkins explained.
The strange discovery, detailed in a paper published July 28 in *Nature,* is the first direct observation of light from behind a black hole -- a scenario that was predicted by Einstein's theory of general relativity but never confirmed, until now.
"Fifty years ago, when astrophysicists starting speculating about how the magnetic field might behave close to a black hole, they had no idea that one day we might have the techniques to observe this directly and see Einstein's general theory of relativity in action," said Roger Blandford, a co-author of the paper who is the Luke Blossom Professor in the School of Humanities and Sciences and Stanford and SLAC professor of physics and particle physics.
How to see a black hole
The original motivation behind this research was to learn more about a mysterious feature of certain black holes, called a corona. Material falling into a supermassive black hole powers the brightest continuous sources of light in the universe, and as it does so, forms a corona around the black hole. This light -- which is X-ray light -- can be analysed to map and characterize a black hole.
The leading theory for what a corona is starts with gas sliding into the black hole where it superheats to millions of degrees. At that temperature, electrons separate from atoms, creating a magnetized plasma. Caught up in the powerful spin of the black hole, the magnetic field arcs so high above the black hole, and twirls about itself so much, that it eventually breaks altogether -- a situation so reminiscent of what happens around our own Sun that it borrowed the name "corona."
"This magnetic field getting tied up and then snapping close to the black hole heats everything around it and produces these high energy electrons that then go on to produce the X-rays," said Wilkins.
As Wilkins took a closer look to investigate the origin of the flares, he saw a series of smaller flashes. These, the researchers determined, are the same X-ray flares but reflected from the *back* of the disk -- a first glimpse at the far side of a black hole.
"I've been building theoretical predictions of how these echoes appear to us for a few years," said Wilkins. "I'd already seen them in the theory I've been developing, so once I saw them in the telescope observations, I could figure out the connection."
Future observations
The mission to characterize and understand coronas continues and will require more observation. Part of that future will be the European Space Agency's X-ray observatory, Athena (Advanced Telescope for High-ENergy Astrophysics). As a member of the lab of Steve Allen, professor of physics at Stanford and of particle physics and astrophysics at SLAC, Wilkins is helping to develop part of the Wide Field Imager detector for Athena.
"It's got a much bigger mirror than we've ever had on an X-ray telescope and it's going to let us get higher resolution looks in much shorter observation times," said Wilkins. "So, the picture we are starting to get from the data at the moment is going to become much clearer with these new observatories."
Co-authors of this research are from Saint Mary's University (Canada), Netherlands Institute for Space Research (SRON), University of Amsterdam and The Pennsylvania State University.
This work was supported by the NASA NuSTAR and XMM-Newton Guest Observer programs, a Kavli Fellowship at Stanford University, and the V.M. Willaman Endowment at the Pennsylvania State University.

- A large tidal stream observed in the Sombrero galaxy

Date: July 21, 2021
Source: Instituto de Astrofísica de Canarias (IAC)

According to the latest cosmological models, large spiral galaxies such as the Milky Way grew by absorbing smaller galaxies, by a sort of galactic cannibalism. Evidence for this is given by very large structures, the tidal stellar streams, which are observed around them, which are the remains of these satellite galaxies. But the full histories of the majority of these cases are hard to study, because these flows of stars are very faint, and only the

remains of the most recent mergers have been detected.
A study led by the Instituto de Astrofísica de Andalucía (IAA-CSIC), with the participation of the Instituto de Astrofísica de Canarias (IAC), has made detailed observations of a large tidal flow around the Sombrero galaxy, whose strange morphology has still not been definitively explained. The results are published today in the journal *Monthly Notices of the Royal Astronomical Society* (MNRAS).
The Sombrero galaxy (Messier 104) is a galaxy some thirty million light years away, which is part of the Local Supercluster (a group of galaxies which includes the Virgo cluster and the Local Group containing the Milky Way). It has roughly one third of the diameter of the Milky Way, and shows characteristics of both of the dominant types of galaxies in the Universe, the spirals and the ellipticals. It has spiral arms, and a very large bright central bulge, which makes it look like a hybrid of the two types.
"Our motive for obtaining these very deep images of the Sombrero galaxy (Messier 104) was to look for the remains of its merger with a very massive galaxy. This possible collision was recently suggested on the basis of studies of the stellar population of its strange halo obtained with the Hubble Space Telescope," says David Martínez-Delgado, a researcher at the IAA-CSIC and first author of the paper reporting the work.
The observations with the Hubble, in 2020, showed that the halo, an extensive and faint region surrounding the Sombrero galaxy, shows many stars rich in metals, elements heavier than hydrogen and helium. This is a feature to typical of new generations of stars, which are normally found in the discs of galaxies, and are quite unusual in galactic halos, which are populated by old stars. To explain their presence astronomers suggested what is known as "a wet merger," a scenario in which a large elliptical galaxy is rejuvenated by large quantities of gas and dust from another massive galaxy, which went into the formation of the disc which we now observe.
"In our images we have not found any evidence to support this hypothesis, although we cannot rule out that it could have happened several thousand million years ago, and the debris is completely dissipated by now - explains David Martínez-Delgado-. In our search we have in fact been able to trace for the first time the complete tidal stream which surrounds the disc of this galaxy, and our theoretical simulations have let us reconstruct its formation in the last three thousand million years, by cannibalism of a satellite dwarf galaxy."
"Observational techniques in present day Astrophysics need advanced image processing. Our modelling of the bright stars around the Sombrero galaxy, and at the same time of the halo light of the galaxy itself has enabled us to unveil the nature of this tidal stream. It is remarkable that thanks to these advanced photometric techniques we have been able to do front line science with a Messier object using only an 18 cm (diameter) telescope," explains Javier Román, a postdoctoral researcher at the IAC and a co-author of the study.
The research team rejects the idea that the large stellar tidal stream, known for more than three decades, could be related to the event which produced the strange morphology of the Sombrero galaxy which, if it was caused by a wet merger, would need the interaction of two galaxies with large masses.
The work has been possible thanks to the collaboration between professional and amateur astronomers. "We have collaborated with the Spanish astrophotographer Manuel Jiménez, who took the images with a robotic telescope of 18 centimetre diameter, and the well-known Australian astrophotographer David Malin, who discovered this tidal stream on photographic plates taken in the 90's of the last century. This collaboration shows the potential of amateur telescopes to take deep images of nearby galaxies which give important clues about the process of their assembly which is continuing until the present epoch," concludes Martínez-Delgado.

- Three dwarf spheroidal galaxies found to rotate

Date: July 27, 2021
Source: Instituto de Astrofísica de Canarias (IAC)

An international team of astrophysicists from the Instituto de Astrofísica de Canarias (IAC), the University of La Laguna (ULL) and the Space Telescope Science Institute (STScI, USA) has discovered the presence of transverse rotation (in the plane of the sky) in three dwarf spheroidal galaxies, a very faint type of galaxies and difficult to observe, which are orbiting round the Milky Way; this helps to trace their evolutionary history. The finding was made using the most recent data from the GAIA satellite of the European Space Agency. The results of the study have just been published in the journal Monthly Notices of the Royal Astronomical Society (MNRAS).
Dwarf galaxies have a particular interest for cosmology. The standard cosmological model suggests that this type of galaxies was the first to form. Many of them, the majority, have been destroyed and cannibalized by large galaxies such as the Milky Way. However, those that remain can be studied and contain valuable information about the early Universe.
One subclass of dwarf galaxies are the dwarf spheroidals. They are very diffuse, with low luminosity, they contain large proportions of dark matter and little or no gas. Since their discovery they have been deeply studied. However, their internal kinematics are still little known, due to the technical difficulties needed for their detailed study.
Various previous studies have shown that the dwarf spheroidals do not have patterns of internal rotation, but their stars move on random orbits predominantly towards and away from the centre of the galaxy. But the galaxies within the other major sub-class of dwarfs, the irregulars, have large quantities of gas, and in some cases do have internal rotation. These differences suggest a different origin for the two types of dwarfs, or to a very different evolutionary history in which interactions with large galaxies, in our case with the Milky Way, have played a crucial role in eliminating the internal rotation of the spheroidals.
To carry out their present research, the team of astrophysicists form the IAC and the STScI have used the latest data from ESA's Gaia to study the internal kinematics of six dwarf spheroidal galaxies, satellites of the Milky Way, and have discovered the presence of transverse rotation (in the plane of the sky) in three of them: Carina, Fornax, and Sculptor. These are the first detections of this type of rotation in dwarf spheroidal galaxies, except for the Sagittarius spheroidal, which is strongly distorted by the gravitational potential of the Milky Way, and is therefore not representative of its type.
"The importance of this result is because, in general, the internal kinematics of galaxies, in this case their rotation, is an important tracer of their evolutionary history, and of the conditions in which the system was formed," explains Alberto Manuel Martínez-García, doctoral student at the IAC and the ULL, and first author of the article.
"Although the standard model of cosmology assumes that the dwarf galaxies were the first to form, it is not clear if they are simple systems or whether those we observe are formed by the agglomeration of other even simpler systems, smaller and older. The presence of rotation suggests the second option. It also suggests a common origin for all dwarf galaxies, those that are at present rich in gas (the irregulars) and those which are not (the spheroidals)," explains Andrés del Pino, researcher at the STScI and a co-author of the article.
"The Gaia satellite has revolutionised our knowledge of the Milky Way and its neighbourhood, giving us very precise measurements of the positions and motions of almost two thousand million stars. Although the data from Gaia are used mainly to study our Galaxy, this ESA mission has also opened a new window on the study of the satellite galaxies of the Milky Way, giving specific access to their internal kinematics," says Antonio Aparicio, a researcher at the IAC and the ULL and a co-author of the article.
Even so, according to the researchers, studies based on Gaia data entail many technical difficulties. In the first place, one must determine which of the stars in the database really belong to the satellite galaxies, and which to the Milky Way itself, as the latter tend to contaminate the sample. The problem is that although the data to be analysed are limited to the region and the angular size of the spheroidal under study, which is the equivalent of one quarter of the angular diameter of the Moon, the vast majority of the stars detected in this area belong to the Milky Way and therefore indeed contaminate the sample.
In addition, the distance of the spheroidals studied, which is up to some half a million light-years, and the low intrinsic luminosity of their stars, imply that the measurements are

affected by a considerable level of noise. For all these reasons the analysis of the data requires a thorough filtration and a deep analysis of the different observational parameters to be able to reach reliable conclusions.

- Astronomers discover how to feed a black hole

Date: July 29, 2021
Source: Instituto de Astrofísica de Canarias (IAC)

The black holes at the centres of galaxies are the most mysterious objects in the Universe, not only because of the huge quantities of material within them, millions of times the mass of the Sun, but because of the incredibly dense concentration of matter in a volume no bigger than that of our Solar System. When they capture matter from their surroundings they become active, and can send out enormous quantities of energy from the capture process, although it is not easy to detect the black hole during these capture episodes, which are not frequent.
However, a study led by the researcher Almudena Prieto, of the Instituto de Astrofísica de Canarias (IAC), has discovered long narrow dust filaments which surround and feed these black holes in the centres of galaxies, and which could be the natural cause of the darkening of the centres of many galaxies when their nuclear black holes are active. The results of this study have recently been published in the journal *Monthly Notices of the Royal Astronomical Society (MNRAS).*
Using images from the Hubble Space Telescope, the Very Large Telescope (VLT) at the European Southern Observatory (ESO), and the Atacama Large Millimetre Array (ALMA) in Chile, the scientists have been able to obtain a direct visualization of the process of nuclear feeding of a black hole in the galaxy NGC 1566 by these filaments. The combined images show a snapshot in which one can see how the dust filaments separate, and then go directly towards the centre of the galaxy, where they circulate and rotate in a spiral around the black hole before being swallowed by it.
"This group of telescopes has given us a completely new perspective of a supermassive black hole, thanks to the imaging at high angular resolution and the panoramic visualization of its surroundings, because it lets us follow the disappearance of the dust filaments as they fall into the black hole," explains Almudena Prieto, the first author on the paper.
The study is the result of the long-term PARSEC project of the IAC, which aims to understand how supermassive black holes wake up from their long lives of hibernation, and after a process in which they accrete material from their surroundings, they become the most powerful objects in the Universe.
Part of this work was carried out within the Master's thesis in Astrophysics of the University of La Laguna of Jakub Nadolny, carried out at the IAC within the PARSEC project. Researchers Mar Mezcua and Juan A. Fernández Ontiveros were also advisers to this work, while they had PARSEC postdoctoral contracts at the IAC.

- Magnetic 'balding' of black holes saves general relativity prediction

Date: July 27, 2021
Source: Simons Foundation

Black holes aren't what they eat. Einstein's general relativity predicts that no matter what a black hole consumes, its external properties depend only on its mass, rotation and electric charge. All other details about its diet disappear. Astrophysicists whimsically call this the no-hair conjecture. (Black holes, they say, "have no hair.")
There is a potentially hairy threat to the conjecture, though. Black holes can be born with a strong magnetic field or obtain one by munching on magnetized material. Such a field must quickly disappear for the no-hair conjecture to hold. But real black holes don't exist in isolation. They can be surrounded by plasma -- gas so energized that electrons have detached from their atoms -- that can sustain the magnetic field, potentially disproving the conjecture.
Using supercomputer simulations of a plasma-engulfed black hole, researchers from the Flatiron Institute's Centre for Computational Astrophysics (CCA) in New York City, Columbia University and Princeton University found that the no-hair conjecture holds. The team reports its findings on July 27 in *Physical Review Letters*.
"The no-hair conjecture is a cornerstone of general relativity," says study co-author Bart Ripperda, a research fellow at the CCA and a postdoctoral fellow at Princeton. "If a black hole has a long-lived magnetic field, then the no-hair conjecture is violated. Luckily a solution came from plasma physics that saved the no-hair conjecture from being broken."

The team's simulations showed that the magnetic field lines around the black hole quickly break and reconnect, creating plasma-filled pockets that launch into space or fall into the black hole's maw. This process rapidly drains the magnetic field and could explain flares seen near supermassive black holes, the researchers report.
"Theorists didn't think of this because they usually put their black holes in a vacuum," Ripperda says. "But in real life, there's often plasma, and plasma can sustain and bring in magnetic fields. And that has to fit with your no-hair conjecture."
Ripperda co-authored the study with Columbia graduate student Ashley Bransgrove and CCA associate research scientist Sasha Philippov, who is also a visiting research scholar at Princeton.
A 2011 study on the problem suggested that the no-hair conjecture was in trouble. However, that study only looked at these systems at low resolution, and it treated plasma as a fluid. However, the plasma around a black hole is so diluted that particles rarely run into one another, so treating it as a fluid is an oversimplification.
In the new study, the researchers conducted high-resolution plasma physics simulations with a general-relativistic model of a black hole's magnetic field. In total, it took 10 million CPU hours to churn through all the calculations. "We couldn't have done these simulations without the Flatiron Institute's computational resources," Ripperda says.
The resulting simulations showed how the magnetic field around a black hole evolves. At first, the field extends in an arc from the black hole's north pole to its south pole. Then, interactions within the plasma cause the field to balloon outward. This opening up causes the field to split into individual magnetic field lines that radiate outward from the black hole. The field lines alternate in direction, either toward or away from the event horizon. Nearby magnetic field lines connect, creating a braided pattern of field lines coming together and splitting apart. Between two such connection points, a gap exists that fills with plasma. The plasma is energized by the magnetic field, launching outward into space or inward into the black hole. As the process continues, the magnetic field loses energy and eventually withers away.
Critically, the process happens fast. The researchers found that the black hole depletes its magnetic field at a rate of 10 percent of the speed of light. "The fast reconnection saved the no-hair conjecture," Ripperda says.
The researchers propose that the mechanism powering observed flares from the supermassive black hole at the centre of the Messier 87 galaxy could be explained by the balding process seen in the simulations. Initial comparisons between them look promising, they say, though a more robust assessment is needed. If they do indeed line up, energetic flares powered by magnetic reconnection at black hole event horizons may be a widespread phenomenon.

- Supernova's 'fizzled' gamma-ray burst

Date: July 26, 2021
Source: NASA/Goddard Space Flight Centre

On Aug. 26, 2020, NASA's Fermi Gamma-ray Space Telescope detected a pulse of high-energy radiation that had been racing toward Earth for nearly half the present age of the universe. Lasting only about a second, it turned out to be one for the record books -- the shortest gamma-ray burst (GRB) caused by the death of a massive star ever seen.
GRBs are the most powerful events in the universe, detectable across billions of light-years. Astronomers classify them as long or short based on whether the event lasts for more or less than two seconds. They observe long bursts in association with the demise of massive stars, while short bursts have been linked to a different scenario.
"We already knew some GRBs from massive stars could register as short GRBs, but we thought this was due to instrumental limitations," said Bin-bin Zhang at Nanjing University in China and the University of Nevada, Las Vegas. "This burst is special because it is definitely a short-duration GRB, but its other properties point to its origin from a collapsing star. Now we know dying stars can produce short bursts, too."
Named GRB 200826A, after the date it occurred, the burst is the subject of two papers published in *Nature Astronomy* on Monday, July 26. The first, led by Zhang, explores the gamma-ray data. The second, led by Tomás Ahumada, a doctoral student at the University of Maryland, College Park and NASA's Goddard Space Flight Centre in Greenbelt, Maryland, describes the GRB's fading multiwavelength afterglow and the emerging light of the supernova explosion that followed.
"We think this event was effectively a fizzle, one that was close to not happening at all,"

Ahumada said. "Even so, the burst emitted 14 million times the energy released by the entire Milky Way galaxy over the same amount of time, making it one of the most energetic short-duration GRBs ever seen."

When a star much more massive than the Sun runs out of fuel, its core suddenly collapses and forms a black hole. As matter swirls toward the black hole, some of it escapes in the form of two powerful jets that rush outward at almost the speed of light in opposite directions. Astronomers only detect a GRB when one of these jets happens to point almost directly toward Earth.

Each jet drills through the star, producing a pulse of gamma rays -- the highest-energy form of light -- that can last up to minutes. Following the burst, the disrupted star then rapidly expands as a supernova.

Short GRBs, on the other hand, form when pairs of compact objects -- such as neutron stars, which also form during stellar collapse -- spiral inward over billions of years and collide. Fermi observations recently helped show that, in nearby galaxies, giant flares from isolated, super magnetized neutron stars also masquerade as short GRBs.

GRB 200826A was a sharp blast of high-energy emission lasting just 0.65 second. After traveling for eons through the expanding universe, the signal had stretched out to about one second long when it was detected by Fermi's Gamma-ray Burst Monitor. The event also appeared in instruments aboard NASA's Wind mission, which orbits a point between Earth and the Sun located about 930,000 miles (1.5 million kilometres) away, and Mars Odyssey, which has been orbiting the Red Planet since 2001. ESA's (the European Space Agency's) INTEGRAL satellite observed the blast as well.

All of these missions participate in a GRB-locating system called the Interplanetary Network (IPN), for which the Fermi project provides all U.S. funding. Because the burst reaches each detector at slightly different times, any pair of them can be used to help narrow down where in the sky it occurred.

About 17 hours after the GRB, the IPN narrowed its location to a relatively small patch of the sky in the constellation Andromeda.

Using the National Science Foundation-funded Zwicky Transient Facility (ZTF) at Palomar Observatory, the team scanned the sky for changes in visible light that could be linked to the GRB's fading afterglow.

"Conducting this search is akin to trying to find a needle in a haystack, but the IPN helps shrink the haystack," said Shreya Anand, a graduate student at Caltech and a co-author on the afterglow paper. "Out of more than 28,000 ZTF alerts the first night, only one met all of our search criteria and also appeared within the sky region defined by the IPN."

Within a day of the burst, NASA's Neil Gehrels Swift Observatory discovered fading X-ray emission from this same location. A couple of days later, variable radio emission was detected by the National Radio Astronomy Observatory's Karl Jansky Very Large Array in New Mexico. The team then began observing the afterglow with a variety of ground-based facilities.

Observing the faint galaxy associated with the burst using the Gran Telescopio Canarias, a 10.4-meter telescope at the Roque de los Muchachos Observatory on La Palma in Spain's Canary Islands, the team showed that its light takes 6.6 billion years to reach us. That's 48% of the universe's current age of 13.8 billion years.

But to prove this short burst came from a collapsing star, the researchers also needed to catch the emerging supernova.

"If the burst was caused by a collapsing star, then once the afterglow fades away it should brighten again because of the underlying supernova explosion," said Leo Singer, a Goddard astrophysicist and Ahumada's research advisor. "But at these distances, you need a very big and very sensitive telescope to pick out the pinpoint of light from the supernova from the background glare of its host galaxy."

To conduct the search, Singer was granted time on the 8.1-meter Gemini North telescope in Hawaii and the use of a sensitive instrument called the Gemini Multi-Object Spectrograph. The astronomers imaged the host galaxy in red and infrared light starting 28 days after the burst, repeating the search 45 and 80 days after the event. They detected a near-infrared source -- the supernova -- in the first set of observations that could not be seen in later ones.

The researchers suspect that this burst was powered by jets that barely emerged from the star before they shut down, instead of the more typical case where long-lasting jets break out of the star and travel considerable distances

from it. If the black hole had fired off weaker jets, or if the star was much larger when it began its collapse, there might not have been a GRB at all.
The discovery helps resolve a long-standing puzzle. While long GRBs must be coupled to supernovae, astronomers detect far greater numbers of supernovae than they do long GRBs. This discrepancy persists even after accounting for the fact that GRB jets must tip nearly into our line of sight for astronomers to detect them at all.
The researchers conclude that collapsing stars producing short GRBs must be marginal cases whose light-speed jets teeter on the brink of success or failure, a conclusion consistent with the notion that most massive stars die without producing jets and GRBs at all. More broadly, this result clearly demonstrates that a burst's duration alone does not uniquely indicate its origin.
The Fermi Gamma-ray Space Telescope is an astrophysics and particle physics partnership managed by NASA's Goddard Space Flight Centre in Greenbelt, Maryland. Fermi was developed in collaboration with the U.S. Department of Energy, with important contributions from academic institutions and partners in France, Germany, Italy, Japan, Sweden, and the United States.

- Astrophysicist outlines plans for the gravitational wave observatory on the moon

Date: July 22, 2021
Source: Vanderbilt University

Vanderbilt astrophysicist Karan Jani has led a series of studies that make the first case for a gravitational wave infrastructure on the surface of the moon. The experiment, dubbed Gravitational-Wave Lunar Observatory for Cosmology, uses the moon's environment and geocentric orbit to analyse mergers of black holes, neuron stars and dark matter candidates within almost 70 percent of the entire observable volume of the universe, he said.
"By tapping into the natural conditions on the moon, we showed that one of the most challenging spectrums of gravitational waves can be measured better from the lunar surface, which so far seems impossible from Earth or space," Jani said.
"The moon offers an ideal backdrop for the ultimate gravitational wave observatory, since it lacks an atmosphere and noticeable seismic noise, which we must mitigate at great cost for laser interferometers on Earth," said Avi Loeb, professor of science at Harvard University and bestselling author of books about black holes, the first stars, the search for extra-terrestrial life and the future of the universe. "A lunar observatory would provide unprecedented sensitivity for discovering sources that we do not anticipate and that could inform us of new physics. GLOC could be the jewel in the crown of science on the surface of the moon."
This work comes as NASA revives its Artemis program, which aims to send the first woman and the next man to the moon as early as 2024. Ongoing commercial work by aerospace companies, including SpaceX and BlueOrigin, also has added to the momentum behind planning for ambitious scientific infrastructure on the surface of the moon.
"In the coming years, we hope to develop a pathfinder mission on the moon to test the technologies of GLOC," Jani said. "Unlike space missions that last only a few years, the great investment benefit of GLOC is it establishes a permanent base on the moon from where we can study the universe for generations, quite literally the entirety of this century." Currently the observatory is theoretical, with Jani and Loeb receiving a strong endorsement from the international gravitational-wave community.
"It was a great privilege to collaborate with an innovative young thinker like Karan Jani," Loeb said. "He may live long enough to witness the project come to fruition."
The work was funded by the Stevenson Chair endowment funds at Vanderbilt University and the Black Hole Initiative at Harvard University, which is funded by grants from the John Templeton Foundation and the Gordon and Betty Moore Foundation.
Video:
https://www.youtube.com/watch?v=Xo2j4E4YDzk

- Martian global dust storm ended winter early in the south

Date: July 22, 2021
Source: Royal Astronomical Society

A dust storm that engulfed Mars in 2018 destroyed a vortex of cold air around the planet's south pole and brought an early spring to the hemisphere. By contrast, the storm caused only minor distortions to the polar vortex in the northern hemisphere and no dramatic seasonal changes. Dr Paul Streeter of The Open University's Faculty of Science, Technology, Engineering and Mathematics will present the work today (23 July) at the virtual National Astronomy Meeting (NAM 2021).

Over two weeks at the beginning of June 2018, localised dust storms combined and spread to form an impenetrable blanket of dust that hid almost the entire planet's surface. The global dust storm, which coincided with Mars's equinox and lasted until mid-September, proved fatal to NASA's solar-powered Opportunity rover.

Streeter and colleagues from The Open University, NASA and the Russian Academy of Sciences examined the effects of the event on the Martian atmosphere by combining data from a Mars Global Climate Model with observations from the European Space Agency/Roscosmos ExoMars Trace Gas Orbiter and NASA's Mars Reconnaissance Orbiter missions.

Dr Streeter said: "This was a perfect opportunity to investigate how global dust storms impact the atmosphere at the Martian poles, which are surrounded by powerful jets of wind in winter. Since the last global storm in 2007, several new missions and instruments have arrived in Mars orbit, so the 2018 event was the most-observed to date."

Previous research has shown that high levels of dust in the atmosphere can have significant effects on polar temperatures and winds. The vortices at the winter poles also affect temperatures and the transport of air, dust, water and chemicals, so their disruption could mean substantial changes in the Martian atmosphere.

The team found that the 2018 storm had profoundly different effects in each hemisphere. At the south pole, where the vortex was almost destroyed, temperatures rose and wind speeds fell dramatically. While the vortex may have already been starting to decay due to the onset of spring, the dust storm appears to have had a decisive effect in ending winter early.

The northern polar vortex, by contrast, remained stable and the onset of autumn followed its usual pattern. However, the normally elliptical northern vortex was changed by the storm to become more symmetrical. The researchers link this to the high dust content in the atmosphere suppressing atmospheric waves caused by the extreme topography in the northern hemisphere, which has volcanoes over twice as tall as Mount Everest and craters as deep as terrestrial mountains.

Dr Streeter added: "Global dust storms at equinox may enhance transport into the southern pole due to the diminished vortex, while the more robust northern vortex continues to act as an effective barrier. If this pattern for global dust storms holds over the course of the thousands of years that Mars maintains this particular axial tilt, it has implications for how dust is deposited at the north and south poles and our understanding of the planet's climate history."

Video:
https://www.youtube.com/watch?v=tCawZig5fCg

- ❖ Unravelling the knotty problem of the Sun's activity

Date: July 22, 2021
Source: Royal Astronomical Society

A new approach to analysing the development of magnetic tangles on the Sun has led to a breakthrough in a longstanding debate about how solar energy is injected into the solar atmosphere before being released into space, causing space weather events. The first direct evidence that field lines become knotted before they emerge at the visible surface of the Sun has implications for our ability to predict the behaviour of active regions and the nature of the solar interior. Dr Christopher Prior of the Department of Mathematical Sciences, Durham University, will present the work today at the virtual National Astronomy Meeting (NAM 2021).

Researchers are generally in agreement that solar activity is caused by instabilities in giant twists of magnetic ropes threading the visible surface of the Sun, known as the photosphere. However, there has been an ongoing debate about how these tangles form. The two dominant theories have suggested either that coils of field lines emerge through the photosphere from the convection zone below, or that the feet of arching field lines wrap around each other on the surface itself and create braids. Both mechanisms could theoretically produce effects like sunspot rotation and dramatic solar flares but, to date, no direct observational evidence had conclusively supported either scenario.

Prior and colleagues from the University of Glasgow and INAF-Osservatorio Astrofisico di Catania in Italy came up with a new direct measure of the entanglement of the magnetic field by tracking the rotation of field lines at the points where they intersect with the photosphere. This 'magnetic winding' should

manifest in different ways for each of the two theories. Thus, applying magnetic winding to observations of the photosphere and examining the resulting patterns could enable a definitive answer to be reached for which theory was correct.
The researchers studied the magnetic winding for 10 active regions on the Sun in observations by solar missions. In every case, the results matched the emergence theory of pre-twisted magnetic field lines rising up from the convection zone.
Prior explains: "The pattern for pre-twisted field lines exactly matched the observational data we considered initially, and this has since been found to be true for all data sets of active regions we have looked at so far. We anticipate that magnetic winding will become a staple quantity in the interpretation of magnetic field structure from observational data."

- Spotted: An exoplanet with the potential to form moons

Date: July 22, 2021
Source: Harvard-Smithsonian Centre for Astrophysics

Astronomers at the Centre for Astrophysics | Harvard & Smithsonian have helped detect the clear presence of a moon-forming region around an exoplanet -- a planet outside of our Solar System. The new observations, published Thursday in *The Astrophysical Journal Letters*, may shed light on how moons and planets form in young stellar systems.
The detected region is known as a circumplanetary disk, a ring-shaped area surrounding a planet where moons and other satellites may form. The observed disk surrounds exoplanet PDS 70c, one of two giant, Jupiter-like planets orbiting a star nearly 400 light-years away. Astronomers had found hints of a "moon-forming" disk around this exoplanet before but since they could not clearly tell the disk apart from its surrounding environment, they could not confirm its detection -- until now.
"Our work presents a clear detection of a disk in which satellites could be forming," says Myriam Benisty, a researcher at the University of Grenoble and the University of Chile who led the research using the Atacama Large Millimetre/submillimetre Array (ALMA). "Our ALMA observations were obtained at such exquisite resolution that we could clearly identify that the disk is associated with the planet and we are able to constrain its size for the first time."
With the help of ALMA, Benisty and the team found the disk diameter is comparable to the Sun-to-Earth distance and has enough mass to form up to three satellites the size of the Moon.
"We used the millimetre emission from cool dust grains to estimate how much mass is in the disk and therefore, the potential reservoir for forming a satellite system around PDS 70c," says Sean Andrews, a study co-author and astronomer at the Centre for Astrophysics (CfA).
The results are key to finding out how moons arise.
Planets form in dusty disks around young stars, carving out cavities as they gobble up material from this circumstellar disc to grow. In this process, a planet can acquire its own circumplanetary disk, which contributes to the growth of the planet by regulating the amount of material falling onto it. At the same time, the gas and dust in the circumplanetary disk can come together into progressively larger bodies through multiple collisions, ultimately leading to the birth of moons.
But astronomers do not yet fully understand the details of these processes. "In short, it is still unclear when, where, and how planets and moons form," explains ESO Research Fellow Stefano Facchini, also involved in the research.
"More than 4,000 exoplanets have been found until now, but all of them were detected in mature systems. PDS 70b and PDS 70c, which form a system reminiscent of the Jupiter-Saturn pair, are the only two exoplanets detected so far that are still in the process of being formed," explains Miriam Keppler, researcher at the Max Planck Institute for Astronomy in Germany and one of the co-authors of the study.
"This system therefore offers us a unique opportunity to observe and study the processes of planet and satellite formation," Facchini adds.
PDS 70b and PDS 70c, the two planets making up the system, were first discovered using ESO's Very Large Telescope (VLT) in 2018 and 2019 respectively, and their unique nature means they have been observed with other telescopes and instruments many times since.
These latest high resolution ALMA observations have now allowed astronomers to

gain further insights into the system. In addition to confirming the detection of the circumplanetary disk around PDS 70c and studying its size and mass, they found that PDS 70b does not show clear evidence of such a disk, indicating that it was starved of dust material from its birth environment by PDS 70c.

An even deeper understanding of the planetary system will be achieved with ESO's Extremely Large Telescope (ELT), currently under construction on Cerro Armazones in the Chilean Atacama desert.

"The ELT will be key for this research since, with its much higher resolution, we will be able to map the system in great detail," says co-author Richard Teague, a co-author and Submillimetre Array (SMA) fellow at the CfA.

In particular, by using the ELT's Mid-infrared ELT Imager and Spectrograph (METIS), the team will be able to look at the gas motions surrounding PDS 70c to get a full 3D picture of the system.

- New study reveals previously unseen star formation in Milky Way

Date: July 22, 2021
Source: National Radio Astronomy Observatory

Astronomers using two of the world's most powerful radio telescopes have made a detailed and sensitive survey of a large segment of our home galaxy -- the Milky Way -- detecting previously unseen tracers of massive star formation, a process that dominates galactic ecosystems. The scientists combined the capabilities of the National Science Foundation's Karl G. Jansky Very Large Array (VLA) and the 100-meter Effelsberg Telescope in Germany to produce high-quality data that will serve researchers for years to come.

Stars with more than about ten times the mass of our Sun are important components of the Galaxy and strongly affect their surroundings. However, understanding how these massive stars are formed has proved challenging for astronomers. In recent years, this problem has been tackled by studying the Milky Way at a variety of wavelengths, including radio and infrared. This new survey, called GLOSTAR (Global view of the Star formation in the Milky Way), was designed to take advantage of the vastly improved capabilities that an upgrade project completed in 2012 gave the VLA to produce previously unobtainable data.

GLOSTAR has excited astronomers with new data on the birth and death processes of massive stars, as well on the tenuous material between the stars. The GLOSTAR team of researchers has published a series of papers in the journal *Astronomy & Astrophysics* reporting initial results of their work, including detailed studies of several individual objects. Observations continue and more results will be published later.

The survey detected tell-tale tracers of the early stages of massive star formation, including compact regions of hydrogen gas ionized by the powerful radiation from young stars, and radio emission from methanol (wood alcohol) molecules that can pinpoint the location of very young stars still deeply shrouded by the clouds of gas and dust in which they are forming.

The survey also found many new remnants of supernova explosions -- the dramatic deaths of massive stars. Previous studies had found fewer than a third of the expected number of supernova remnants in the Milky Way. In the region it studied, GLOSTAR more than doubled the number found using the VLA data alone, with more expected to appear in the Effelsberg data.

"This is an important step to solve this longstanding mystery of the missing supernova remnants," said Rohit Dokara, a Ph.D student at the Max Planck Institute for Radioastronomy (MPIfR) and lead author on a paper about the remnants.

The GLOSTAR team combined data from the VLA and the Effelsberg telescope to obtain a complete view of the region they studied. The multi-antenna VLA -- an interferometer -- combines the signals from widely-separated antennas to make images with very high resolution that show small details. However, such a system often cannot also detect large-scale structures. The 100-meter-diameter Effelsberg telescope provided the data on structures larger than those the VLA could detect, making the image complete.

"This clearly demonstrates that the Effelberg telescope is still very crucial, even after 50 years of operation," said Andreas Brunthaler of MPIfR, project leader and first author of the survey's overview paper.

Visible light is strongly absorbed by dust, which radio waves can readily penetrate. Radio telescopes are essential to revealing the dust-shrouded regions in which young stars form.

The results from GLOSTAR, combined with other radio and infrared surveys, "offers astronomers a nearly complete census of massive star-forming clusters at various stages of formation, and this will have lasting value for future studies," said team member William Cotton, of the National Radio Astronomy Observatory (NRAO), who is an expert in combining interferometer and single-telescope data.

"GLOSTAR is the first map of the Galactic Plane at radio wavelengths that detects many of the important star formation tracers at high spatial resolution. The detection of atomic and molecular spectral lines is critical to determine the location of star formation and to better understand the structure of the Galaxy," said Dana Falser, also of NRAO.

The initiator of GLOSTAR, the MPIfR's Karl Menten, added, "It's great to see the beautiful science resulting from two of our favourite radio telescopes joining forces."

The National Radio Astronomy Observatory is a facility of the National Science Foundation, operated under cooperative agreement by Associated Universities, Inc.

- Planetary shields will buckle under stellar winds from their dying stars

Date: July 22, 2021
Source: Royal Astronomical Society

Any life identified on planets orbiting white dwarf stars almost certainly evolved after the star's death, says a new study led by the University of Warwick that reveals the consequences of the intense and furious stellar winds that will batter a planet as its star is dying. The research is published in Monthly Notices of the Royal Astronomical Society, and lead author Dr Dimitri Veras will present it today (21 July) at the online National Astronomy Meeting (NAM 2021).

The research provides new insight for astronomers searching for signs of life around these dead stars by examining the impact that their winds will have on orbiting planets during the star's transition to the white dwarf stage. The study concludes that it is nearly impossible for life to survive cataclysmic stellar evolution unless the planet has an intensely strong magnetic field -- or magnetosphere -- that can shield it from the worst effects.

In the case of Earth, solar wind particles can erode the protective layers of the atmosphere that shield humans from harmful ultraviolet radiation. The terrestrial magnetosphere acts like a shield to divert those particles away through its magnetic field. Not all planets have a magnetosphere, but Earth's is generated by its iron core, which rotates like a dynamo to create its magnetic field.

"We know that the solar wind in the past eroded the Martian atmosphere, which, unlike Earth, does not have a large-scale magnetosphere. What we were not expecting to find is that the solar wind in the future could be as damaging even to those planets that are protected by a magnetic field," says Dr Aline Vidotto of Trinity College Dublin, the co-author of the study.

All stars eventually run out of available hydrogen that fuels the nuclear fusion in their cores. In the Sun the core will then contract and heat up, driving an enormous expansion of the outer atmosphere of the star into a 'red giant'. The Sun will then stretch to a diameter of tens of millions of kilometres, swallowing the inner planets, possibly including the Earth. At the same time the loss of mass in the star means it has a weaker gravitational pull, so the remaining planets move further away.

During the red giant phase, the solar wind will be far stronger than today, and it will fluctuate dramatically. Veras and Vidotto modelled the winds from 11 different types of stars, with masses ranging from one to seven times the mass of our Sun.

Their model demonstrated how the density and speed of the stellar wind, combined with an expanding planetary orbit, conspires to alternatively shrink and expand the magnetosphere of a planet over time. For any planet to maintain its magnetosphere throughout all stages of stellar evolution, its magnetic field needs to be at least one hundred times stronger than Jupiter's current magnetic field.

The process of stellar evolution also results in a shift in a star's habitable zone, which is the distance that would allow a planet to be the right temperature to support liquid water. In our solar system, the habitable zone would move from about 150 million km from the Sun -- where Earth is currently positioned -- up to 6 billion km, or beyond Neptune. Although an orbiting planet would also change position during the giant branch phases, the scientists found that the habitable zone moves outward more quickly than the planet, posing additional challenges to any existing life hoping to survive the process.

Eventually the red giant sheds its entire outer atmosphere, leaving behind the dense hot white dwarf remnant. These do not emit stellar winds, so once the star reaches this stage the danger to surviving planets has passed.

Dr Veras said: "This study demonstrates the difficulty of a planet maintaining its protective magnetosphere throughout the entirety of the giant branch phases of stellar evolution."

"One conclusion is that life on a planet in the habitable zone around a white dwarf would almost certainly develop during the white dwarf phase unless that life was able to withstand multiple extreme and sudden changes in its environment."

Future missions like the James Webb Space Telescope due to be launched later this year should reveal more about planets that orbit white dwarf stars, including whether planets within their habitable zones show biomarkers that indicate the presence of life, so the study provides valuable context to any potential discoveries.

So far no terrestrial planet that could support life around a white dwarf has been found, but two known gas giants are close enough to their star's habitable zone to suggest that such a planet could exist. These planets likely moved in closer to the white dwarf as a result of interactions with other planets further out.

Dr Veras adds: "These examples show that giant planets can approach very close to the habitable zone. The habitable zone for a white dwarf is very close to the star because they emit much less light than a Sun-like star. However, white dwarfs are also very steady stars as they have no winds. A planet that's parked in the white dwarf habitable zone could remain there for billions of years, allowing time for life to develop provided that the conditions are suitable."