New Zenith

The Monthly Newsletter of the Vectis Astronomical Society

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Society News

My Last New Zenith

Well, after volunteering to be NZ editor back in October 2007, it's time for me to hand over to somebody else.

Thankfully **Simon Gardner** has agreed to take the reigns for future issues.

I'll be continuing as Observatory Director and will of course help Simon as he gets used to things.

Thanks to everyone who has helped me with NZ over the years and the 150 odd editions(!).

I wish Simon Gardner success in his new position as New Zenith Editor.

Observatory Maintenance

Repairs to the leaking observatory dome have begun and are going well.

In the past, some of the panels which make up the dome had been repaired using various fillers and mastics. Unfortunately, some of these repairs had failed allowing rainwater to accumulate behind the filler and eventually make its way through panel joints to the inside.

After a good clean (and rust removal or treatment) of the affected areas, a continuos fillet of fibreglass has been applied to ensure a fully waterproof seals.

There is still a fair bit to do and we'll be dependant on the weather whilst this happens.

Please bear with us and please don't forget:

The Observatory Dome is out of bounds during the repair work. If for any reason you need access to the area, please contact me or Dudley Johnson

Brian Curd

VAS Website: wightastronomy.org

Submissions or letters to New Zenith are always welcome and should be sent to:

The Editor, New Zenith

Email: **editor@wightastronomy.org**

Material for the next issue by the 6th of the month please.

Observatory Diary

Monday, 19.30hrs	Members Only and by arrangement Telescope and night sky training.
Thursday	Members (19.30hrs) and Public (20.00hrs). Informal meeting and observing

VAS Website: wightastronomy.org

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2023 Monthly Meetings

Check *http://www.wightastronomy.org/meetings/* for the latest information

Date	Subject	Speaker
22 Sep	**ZOOM Only** Celestial Hide and Seek Eclipses, Transits and Occultations	Martin Lunn
27 Oct	**ZOOM Only** The Great Debate (The Shapley-Curtiss Debate of 1920)	Nick Hewitt
24 Nov	The Story of Radio Astronomy	James Fradgley
2024 Monthly Meetings		
2024 26 Jan	GW Astronomy - Updates from the LIGO/Virgo/ KAGRA 4th Observing Run	Dr Laura Nuttall

Observatory Visits Booked

No bookings so far

Please phone me for the current situation (number on the front page)

It would be appreciated if members could avoid using the observatory at these times.

GDPR rules mean we must maintain accurate membership records, please tell us if your contact details changes

VAS Contacts 2023

President	Barry Bates president@wightastronomy.org
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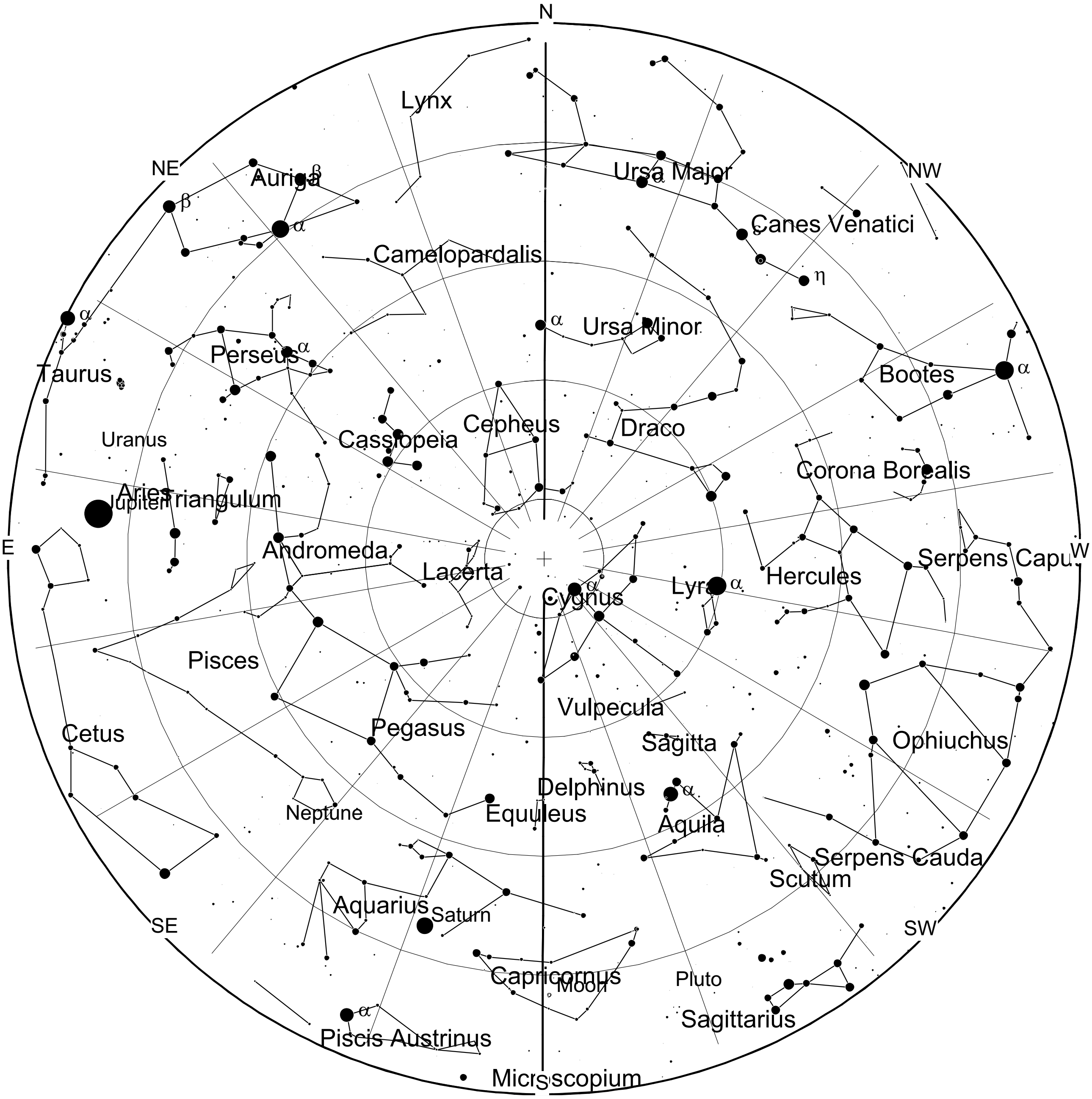
Important

Members using the observatory MUST enter a line or two in the Observatory Log Book.

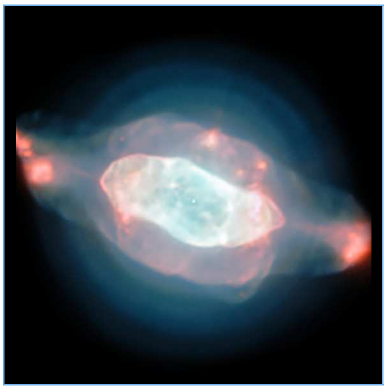
On several occasions, lights, heaters and the Meade LX200 have been left on!

When leaving, please ensure all is secure and all lights, heaters and telescopes are TURNED OFF.

September 2023 - Sky Map



View from Newchurch Isle of Wight UK - 2200hrs - 20 September 2023



The **Saturn Nebula** (also known as NGC 7009 or Caldwell 55) is a planetary nebula in the constellation Aquarius. It appears as a greenish-yellowish hue in a small amateur telescope. It was discovered by William Herschel on September 7, 1782, using a telescope of his own design in the garden at his home in Datchet, England, and was one of his earliest discoveries in his sky survey.

The nebula was originally a low-mass star that ejected its layers into space, forming the nebula. The central star is now a bright white dwarf star of apparent magnitude 11.5.

September - Night Sky

Autumnal Equinox

The Autumnal Equinox, the time at which the Sun crosses the equator on its way south, and day and night are of equal length is on September 23 at 06:50 UTC.

Moon Phases

New	First Qtr	Full	Last Qtr
15th	22nd	29th	6th
●	◐	○	◑

Planets

Mercury

Towards the end of the month Mercury makes an appearance low down in the morning sky just before sunrise. By the 20th will have brightened enough against the morning twilight to be relatively easy to see. At 6AM it can be found low down, close to the eastern horizon. The much brighter Venus can be used as a guide, follow a line from Venus to the point where the Sun will rise. The bright point of light about 5 degrees above the horizon is Mercury. A pair of binoculars will help to see this elusive little world.

Venus

Venus has now overtaken us on its path around the Sun and has moved into the morning sky. Look low down in the east before sunrise. At the start of the month it rises just after 5AM and as the days pass and the sky gets darker becomes easier to spot.

Mars

Mars is now close to the Sun at sunset and as such is not available for observation. It will become visible again next year when it returns to the morning sky.

Jupiter

At the start of the month Jupiter rises just before 10PM and is visible until sunrise. Being one of the brightest objects in the night sky it is easy see and to identify. By about 11PM it will have cleared the horizon and will be seen shining brightly in the eastern sky; far brighter than any star. A small telescope will show the cloud bands and if the seeing is good and the timing right, the great red spot.

Saturn

Saturn was at opposition and best placed for observation in late August. It is however still well placed passing due south at around midnight. Although noticeably fainter than Jupiter it is brighter than any star in that part of the sky. A telescope will show the rings which are now closing and by next year will be almost invisible.

Uranus

Uranus is to be found in the constellation of Aries. It is approximately half way between the bright planet Jupiter and the Pleiades star cluster. The finder chart shows the position of Uranus at the first of each month from the first of September until the first of April 2024.

Neptune

Neptune is below the circlet of Pisces and has no easy to use guide stars close by. To locate it use the finder chart in the July New Zenith or use a planetarium program

Deep Sky

NGC7009 The Saturn Nebula
RA 21h 5m Dec -11° 20' mag 8.3

Originally discovered by William Herschel in 1782 and named by Lord Rosse who saw its elongated shape for the first time. This tiny nebula is one of the few that can show some hint of colour, usually reported as light green. The high brightness allows the use of fairly high magnification and being so small this is needed if the Saturn shape is to be seen.

M73 Star Cluster
RA 20h 59m Dec -12° 36' mag 9.0

This is a grouping of just four stars that form a Y pattern or perhaps a lambda depending on which way up it appears. The stars can be resolved in the smallest of telescopes used today and shows no sign of nebulosity. This is perhaps another pointer to the quality of some optical instruments being used in Messier's time that he mistook this object for something that looked like a comet. It is not known if this is just a chance alignment of stars or whether they form a true cluster.

M15 Globular Cluster
RA 21h 30m Dec 12° 10' mag 7.5

This impressive globular is quite bright and very easily found in binoculars. Follow the line from Baham to Enif, about 4 degrees beyond the horse's nose to find this rather large fuzzy looking star. Through a telescope it reveals its self as a bright core surrounded by a halo of much fainter stars. As with all globulars the view becomes more impressive with increasing aperture. This is one of only a few globular clusters to contain a planetary nebula, it is however about 14th magnitude and for visual beyond all but those with the largest telescopes and best eyes.

Peter Burgess

Variable Stars - An Introduction

Review of the July 2023 monthly talk given by VAS Chairman Bryn Davis

Why do stars vary in brightness? This simple question opens up a field of astronomy that could last a lifetime! Bryn's excellent talk introduced us to the dizzying variety of causes, many of which are the subject of current research. But you don't need a space telescope to explore variable stars for yourself - in fact, some effects were visible to the naked eye long before telescopes were invented. The lecture also brought to our attention the superb observational work of a founder VAS member, Kevin West, as an example of what can be achieved by a practised and dedicated amateur astronomer.

History

A whistlestop tour through the centuries began with a 5,600-year-old rock carving in Kashmir through to the astonishing discoveries of the Kames Webb Space Telescope. Chinese astronomers in the 11th century recorded a supernova, the remnants of which we can observe today as the Crab Nebula. We met some fascinating characters along the way: the pioneer English observer John Goodricke, who studied the behaviour of Algol; Friedrich Argelander the German scientist who developed the system of naming variable stars; and the brilliant American woman Henrietta Swan Leavitt, whose extraordinary skill in charting Cepheid variable stars, and linking their inherent luminosity with the variable period, supplied Edwin Hubble with the data to infer the model of an expanding universe.

Figure 1 - An ancient rock carving from Kashmir overlaid on a star chart, suggesting the position of a supernova, a "second sun" (Credit: The Guardian 10 Jan 2018)

Observing

How can we identify a variable star and how are measurements made to measure their brightness and how it changes? Observers with good eyesight and a dark sky should be able to distinguish the brightness of stars down to about the 6th magnitude, but binoculars or a telescope would be needed for fainter targets. The simplest original manual methods would involve comparing the star of interest with at least 2 stars of known (and unvarying) magnitude within the same field of view. With other techniques, as well as practise and extraordinary patience, estimates of 1/10th of a magnitude can be made. The same star would be observed many times, with the time and magnitude recorded in order to chart a "light curve" which reveals the shape of the variation and any periodicity.

Types of Variable Star

Variable stars are divided into two broad categories: intrinsic and extrinsic. For intrinsic variables, it is the properties and structure of the star itself that affects the brightness, whereas for the extrinsic type it is something other than the star itself that causes the variation.

Figure 2 - The "Harvard Computers" at work in the 1880s, including Henrietta Swan Leavitt and Williamina Fleming (Credits: Harvard College Observatory / wikimedia.org)

Intrinsic classes include:

- Cataclysmic Variables: these are often stars at the end of their life or in the process of undergoing a transition, including various types of supernovae.

- Pulsating Variables: of the many types that have been listed under this category, the two most common and important ones are Cepheid and RR Lyrae types. A Cepheid is a very large star which expands and shrinks with precise regularity (often over 1-100 days), and as mentioned above this can be used to estimate the inherent luminosity (how bright the star really is), which when compared with the apparent luminosity (how bright it appears to us on Earth), tells us how far away it is even if it is in a distant galaxy. RR Lyrae types are named after the variable star in the constellation of Lyra, and were discovered by another great pioneer astronomer, **Williamina Fleming** in 1899.

- Rotating Variables: stars rotate on their axis - as almost everything in the universe does - so if there is any difference in brightness between one side of a star and the other, then we can observe a regular brightening and dimming. For example, our Sun has dark sunspots that may appear in clusters, and other stars have been found that have more pronounced dark patches. But there can be many factors that can cause the effect.

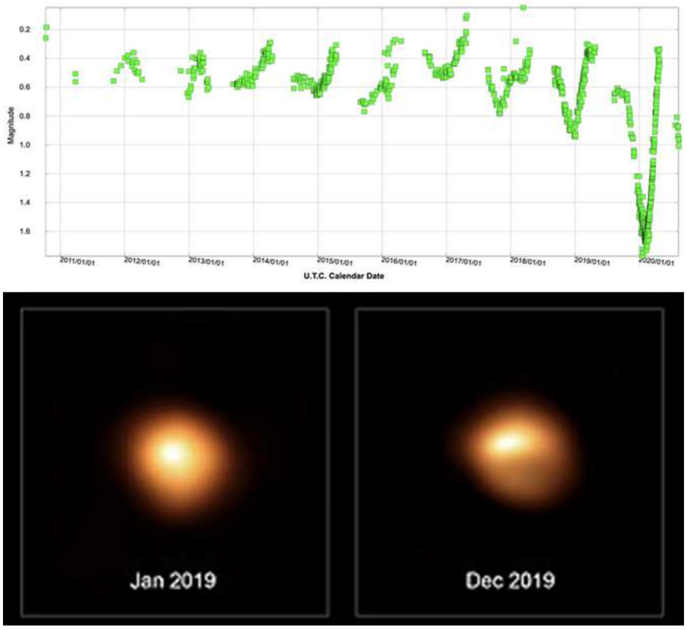


Figure 3 - The dimming of Betelgeuse has been the subject of much interest recently. The light curve shows increased dips in brightness. Evidence from the VLT (Very Large Telescope in South Africa) suggests a passing dust cloud obscured the view.Unmasking the Universe: Astrophysicist Catalogs All Known Planet-Hosting, Three-Star Systems

Extrinsic classes include various eclipsing types, where components of a binary system pass in front of each other, as well as planetary systems:

- Type EA is named after Algol which is a binary star in which the two stars far enough apart for clear regular dips in the light curve to be seen when they eclipse each other. [Incidentally, medieval Islamic scholars knew the star Algol as the “winking demon” which shows that they knew about the variable brightness. - SG]

- Type EB is the ?-Lyrae type in which the two stars in a binary system are close enough that is causes tidal distortions in the two components. This results in continuously changing brightness.

- Type EW (named for W Ursa Majoris, in the Great Bear constellation) consists of binary stars that are so close together that they are nearly touching. Characteristically such systems have primary and secondary eclipses that are very similar and periods are very short, about 1 day.

- Type EP is the class in which extrasolar planets eclipse their star. Observations of the resulting dips in brightness as the planet passes in front of the star, have been a primary source of evidence for the existence of planets outside of the solar system, and with space telescope measurements can even characterise the size and nature of the newly-discovered planets.

Kevin West

Finally, Bryn presented some of the work of VAS founder member Kevin West who, during the 1990s, studied several higher declination northern variable stars. He used a single pixel photometer to record the magnitudes of certain variable stars and constructed light curves, sometimes making multiple observations on a single target over the course of the whole night. We saw several examples of the resulting light curves, which everyone present found very impressive. Kevin's work contributed significantly to collaborative efforts with professional astronomers, including his discovery of the 6th magnitude variable star BR Canes Venaticum, which is a slow irregular pulsating red giant (with a period of just over 6 hours. Kevin was honoured by receiving the prestigious Steavenson Award from the BAA in 2002. What an inspiration!

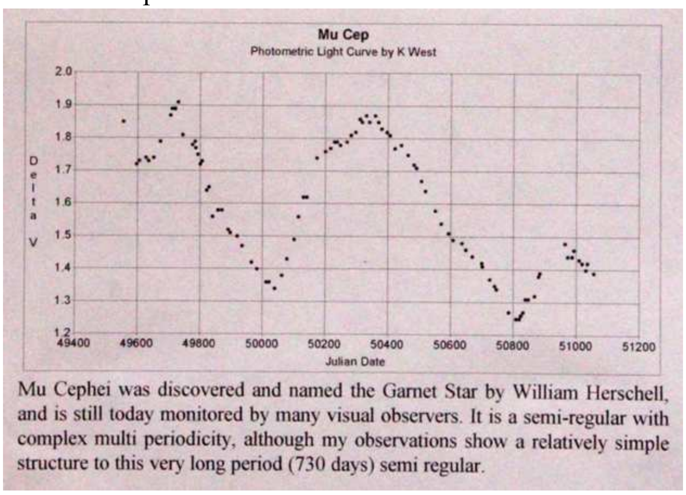
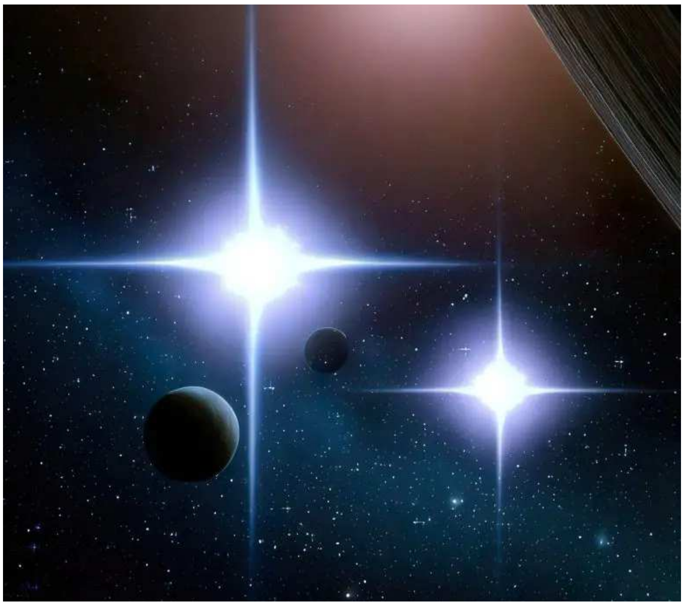


Figure 4 - A light curve compiled by Kevin West: the result of many patient hours observations over nearly 4 years. Note the use of the Julian date on the time axis.

This article was prepared by Simon Gardner, with many thanks to Bryn both for his talk and for generously sharing his presentation material.

Unmasking the Universe: Astrophysicist Catalogs All Known Planet-Hosting, Three-Star Systems



A study led by a University of Texas planetary physicist has compiled an exhaustive catalog of all known planet-hosting triple-stellar systems, considering different types of planetary orbits and examining past controversies. It suggests that triple-stellar system planets, which account for about 0.5% of all known planets, are mostly Jupiter-type and highlights that these systems' formation and orbital stability present theoretical challenges.

In triple-stellar systems, a pair of stars orbit each other while a third star orbits around the pair.

Manfred Cuntz, a planetary physicist from The University of Texas at Arlington, has led a new study that catalogs all known planet-hosting, triple-stellar systems - those having three or more stars with planets.

The project, titled "An Early Catalog of Planet-hosting Multiple-star Systems of Order Three and Higher" provides a thorough bibliographic assessment of planet-hosting, triple-stellar systems.

It was recently published in The Astrophysical Journal Supplements, a journal of the American Astronomical Society that has one of the highest impact factors in the field. Co-authors include UTA alumni G.E. Luke, Matthew Millard, and Lindsey Boyle, as well as Shaan D. Patel, a doctoral-bound graduate student.

The paper offers a system classification that considers the various types of planetary orbits among other factors. Additionally, the authors examine past controversies and planet retractions based on the criteria for what constitutes a planet-hosting, triple-stellar system.

Most planets, such as all in Earth's solar system, orbit a single star. About 100 known planets are members of stellar binaries, the authors wrote in their study.

"The number of planets found to be hosted by higher-order systems is relatively small - about 40 for triple and quadruple systems combined, with the exact number depending on whether some controversial or unconfirmed cases are included," Cuntz said. "The number of confirmed planets in triple-stellar systems currently stands at about 30, which is approximately 0.5% of the total number of planets identified. This aspect makes those planets very special."

The NASA Kepler Space Telescope, which was operational from 2009-18, aided in the science of discovering planet-hosting, triple-stellar systems, Cuntz said. Scientists expect the number of known systems to increase, particularly with the abilities of the James Webb Space Telescope, which was launched in 2021.

The authors note that the overwhelming majority of triple-stellar system planets are Jupiter-type, meaning they are gas giants, and the host stars are relatively massive, compared to typical main-sequence stars. However, some Earth-mass planets have been found as well.

Triple-stellar systems can be divided into two subgroups, each of which travels in a relatively large orbit around the system's center of mass. In a triple-stellar system, two of the stars usually form a close binary pair (two stars that are gravitationally bound to and in orbit around each other), and the third orbits that pair from a farther distance. Systems with more than three stars are expected to produce even more complicated orbiting arrangements.

"The existence of planets in triple-star systems is extremely challenging theoretically, both regarding their formation and orbital stability," Cuntz said. "These topics are a stark motivation of future UTA research, also involving students."

More at: https://scitechdaily.com/

Webb Telescope Tracks Universe's First Light

New results from the James Webb Space Telescope find that radiation from ordinary galaxies cleared the primordial haze left over from the Big Bang, allowing the first light to shine through the early universe.

In the early days of the universe, as the first stars were forming, the space between galaxies was filled with an opaque fog of neutral hydrogen. But these dark ages didn't last. By around 1 billion years after the Big Bang, ultraviolet radiation had ionized the space between stars. The universe became transparent, and photons were free to travel the cosmos.

Until now, though, the origin of the ultraviolet light that created the epoch of reionization was still a mystery.

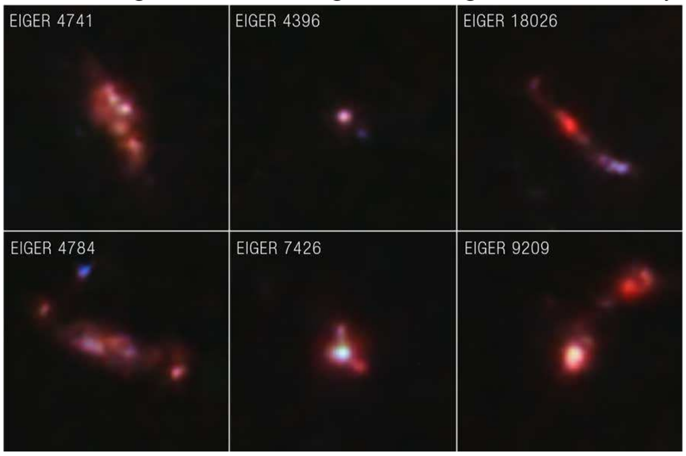
The EIGER Project, led by Simon Lilly (ETH Zurich, Switzerland), just published a series of three papers in The Astrophysical Journal, in which they used the Near-Infrared Camera on the James Webb Space Telescope (JWST) alongside ground-based observations from the Very Large Telescope, Magellan, and Keck Telescopes to observe one of the brightest, most distant quasars known, SDSS J0100+2802.

This quasar's gas-guzzling supermassive black hole generates a brilliant beacon of light that illuminates the gas all along the line of sight between us and it. Astronomers can thus use the quasar to probe the state of gas around intervening galaxies — especially faraway galaxies that might be associated with reionization.

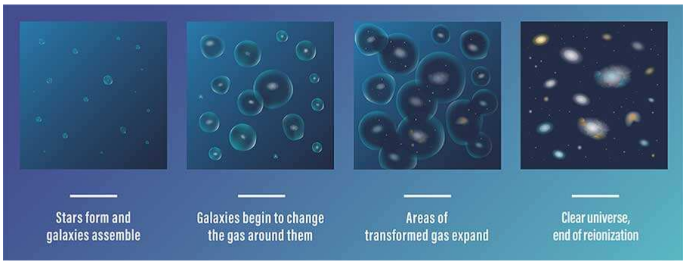
"We had the perfect complementarity of the world's best ground-based telescopes, giving us the quasar spectrum," Lilly says, "and the beautiful Webb, which was able to get spectroscopic data on a large number of galaxies at this very interesting epoch."

The first study, led by Daichi Kashino (Nagoya University, Japan), reports the detection of 117 late-reionization galaxies in the line of sight between us and the quasar. We already knew that during this time period, the space between galaxies is partly hazy, partly clear. This study connects the aforementioned galaxies with transparent "bubbles" of space, where photons are able to travel freely. The further back in time toward the quasar we look, the smaller the bubbles around the galaxies appear to be.

The second study, led by Jorryt Matthee (also at ETH Zurich), characterized each of the 117 galaxies in question. They are all small, young, and chaotic, with lots of star formation and supernovae. The radiation from all this activity would have been sufficient to ionize the space around the galaxies, allowing the first light to travel freely.



The third study, led by Ann-Christina Eilers (MIT), focused on the quasar itself, which is the most luminous quasar known in the early universe. They verified previous measurements of its mass, and they determined that it probably wasn't gravitationally lensed — meaning it's exactly as bright as it seems to be. (The quasar's enormous mass so early in the universe is hard to explain, but that's a mystery for another day).



The late-reionization space environment was already known to host lingering patches of opaque haze, interspersed with ever-growing regions where light could shine freely. But what had cleared out the transparent bubbles: brilliant quasars or ordinary galaxies?

For a time, astronomers suspected quasars did all the work. But George Becker (University of California Riverside), who was not involved with these studies, says that idea has its own problems. "This quasar is special because it's extremely bright, and at this point in time, it has ionized a very large bubble around it," he explains. "But there simply aren't enough quasars out there to have reionized the whole universe by that time."

"We suspected star-forming galaxies were mainly responsible," he adds, "but it was unclear whether enough of their ionizing radiation actually made it out into deep space."

Now, astronomers have shown that it's possible. JWST's camera has a mode that allows it to take a spectrum of every galaxy in its field of view. Using this mode, which was originally intended for calibration purposes, the EIGER team showed that the bubbles of transparent, ionized gas seen in the quasar's spectrum were in fact associated with the exact locations of the star-forming galaxies seen by JWST. This supports the idea that ordinary galaxies did most of the work clearing the space around them.

The EIGER project is currently looking over similar data from five other quasars from this early era. And they aren't the only ones. Becker, who's currently leading a JWST program called "How Does Reionization End?", summarizes his "competitors" research:

"They are providing exciting and important insight into three key questions: How the universe was reionized, how supermassive black holes formed in the early universe, and what were the properties of the first galaxies. It's great work!"

Even though JWST has been in operation for a little less than a year, EIGER and other groups are already well placed to solve one of the biggest mysteries in cosmology. And this is just the beginning.

From: https://skyandtelescope.org/

Reconstructing an Alien Astronomer's View of Our Home Galaxy's Chemistry

Researchers have reconstructed what alien astronomers observing our Milky Way galaxy from afar would find if they analyzed our home galaxy's chemical composition. The study, which is led by researchers from the Max Planck Institute for Astronomy, is relevant for our own understanding of the cosmos: It allows for a new kind of comparison between our home galaxy and the many distant galaxies that we observe from the outside. The results provide part of the answer to the old question whether our home galaxy is special: at least when it comes to chemical composition, the Milky Way is unusual, but not unique.

We see distant galaxies from the outside: Telescope observations show us a galaxy's shape and its spectrum (the rainbow-like decomposition of a galaxy's light). So how would our own galaxy look from that perspective, to a distant, alien astronomer? That is a deceptively simple question. After all, astronomers here on Earth have devised quite ingenious ways of deducing a galaxy's properties from what we observe, and alien astronomers will likely have a similarly sophisticated view of the Milky Way.

For the more sophisticated methods of analysis, it is not at all easy to tell what alien astronomers would find, were they to apply those methods to our home galaxy. But the pay-off can be considerable. Jianhui Lian (Max Planck Institute for Astronomy and Yunnan University), the lead author of the study that has now been published in Nature Astronomy, says, "Finding ways to compare our home galaxy with more distant galaxies is what we need if we want to know whether the Milky Way is special or not. This has been an open question since astronomers realized a hundred years ago that the Milky Way is not the only galaxy in the universe."

Great strides for data and simulations

As old as the question may be, it looks like astronomy is right now in a good position to find a solid answer. For one, in the past decade or so, there has been tremendous progress in systematic studies of our home galaxy. There have been surveys, such as APOGEE, providing information about the chemical composition, physical properties and 3D motions of millions of individual stars in our Milky Way deduced from their spectra. ESA's Gaia spacecraft has tracked the brightness, motion and distance for nearly 1.5 billion stars in our home galaxy.

There is also much more and much better data for distant galaxies. The MaNGA survey studied nearly 10,000 galaxies in depth. Where previous surveys targeting that many galaxies would only provide one overall spectrum per galaxy, MaNGA paints a "spectral picture," showing how, say, each galaxy's chemical composition varies from the center to the outer regions.

Last but not least, there are now modern simulations of galaxy formation and evolution, like the TNG50 simulation that follows the history of thousands of galaxies in a model universe from after the Big Bang to the present time. All these developments where necessary for us to predict what alien astronomers would see as they pointed their telescopes towards the Milky Way and attempted to reconstruct the galaxy's chemical composition.

Second-guessing alien astronomers

This is just what a new study led by Lian and Maria Bergemann (Max Planck Institute for Astronomy) did. Specifically, Lian, Bergemann and their colleagues considered the chemical composition of stars. The stars we see around us consist mostly of hydrogen and helium, but there is a smattering of elements heavier than helium - elements that, in astronomy (but not in ordinary chemistry!) are called "metals."

Some of these metals are produced inside stars, and flung into space when massive stars explode at the end of their lives. Others are produced in the outer layers of bloated giant stars, and set to drift out into space from there. And most importantly, there is a general trend: The concentration of metals in the interstellar medium - the low-density mix of gas and dust that fills the space between the stars - increases over time. Stars that were born earlier contain fewer metals, later-born stars contain more. Mapping out which regions of a galaxy has stars with fewer or with more metals tells you which region formed its stars earlier and which region later.

From local cosmology to an alien perspective

Our home galaxy, the Milky Way, is currently the only spiral galaxy in which we can directly make a large-scale survey of individual stars - measure their positions within our galaxy and, via their spectra, their metal content, surface temperature and other physical properties. Lian, Bergemann and their colleagues set out to reconstruct what alien astronomers would see if they were to map the prevalence of metals in the Milky Way. Since our home galaxy is a disk galaxy, the key question is: How would a distant alien astronomer see the abundance of metals vary depending on the distance of a region from the center of our galaxy?

This kind of reconstruction takes work. The data from the APOGEE survey was only the starting point. Next, the researchers needed account for the fact that, from Earth, we have a “smudgy” view of the Milky Way: In some directions, there will be more dust between us and more distant stars, attenuating the star light and hiding some of the dimmest stars altogether. In other directions there will be less dust. The researchers needed to combine the observation data with what we know about dust and about the properties of stars in order to reconstruct the real distribution of stars in our galaxy.

Our galaxy's high-metallicity 'belt'

The results were somewhat surprising. If you track the average metal content of stars from the galaxy center outwards, it will increase, reaching a metal content close to that of our sun at a distance of about 23,000 light-years from the center. (For comparison: our sun is at about 26,000 light-years from the galactic center.) At an even greater distance, the average metal content goes down again, dropping to roughly one third of the solar value at around 50,000 light-years from the center.

In order to understand what was going on, the researchers then looked separately at stars of different age groups - the APOGEE spectra allow for at least a rough estimate of stellar age. Looking at younger and older stars separately, they found that each age group basically followed an unbroken trend with higher metal content closer to the center, lower content further out. The increase and maximum of the overall distribution was purely due to older stars (with much lower metal content) being more abundant near the galactic center and thus pulling down the overall average, but with younger stars becoming more frequent further out.

Comparing our Milky Way with other galaxies

Lian, Bergemann and their colleagues compared this interesting result with the properties of other galaxies. On the one hand, they considered 321 galaxies in the MaNGA survey, all of which have masses similar to the Milky Way, produce similar amounts of stars and all of which are visible face-on, so the change of average metallicity could be measured. On the other hand, the researchers used the same criteria to identify 134 Milky-Way-like galaxies in the model universe of the TNG50 simulation.

So just how special is our home galaxy - or not? The answer provided by the present study: When it comes to the distribution of metal abundances, our Milky Way is unusual, but not unique. Only 11% of the galaxies in the TNG50 sample and about 1% galaxies in the MaNGA sample showed a similar up-and-down of average metallicity. The discrepancy between 11% and 1% is likely to be due to a combination of uncertainties in the MaNGA data and the limitation of realistic simulations in the TNG50 model universe.

In addition, in the outer regions, the decrease in average metallicity with increasing distance from the center is rather more steep for the Milky Way, compared with the MaNGA and TNG50 galaxies.

The question of 'why'

So why does the Milky Way have the unusual properties it has, and what do these properties mean for our home galaxy's formation history? There are several ways of explaining comparative scarcity of metal-rich stars near the galactic center. This feature could be related to the formation of the so-called bulge, a roughly spherical region of older star surrounding the galactic center out to distance of about 5,000 light-years. Bulge formation would have used most of the available hydrogen gas, making later star formation much more difficult. Alternatively, the scarcity could be related to an active phase in which our galaxy's central supermassive black hole spewed out particles and radiation from its immediate neighborhood, inhibiting star formation.

The metallicity in the outer regions can be explained by several scenarios that combine the evolution of gas within our home galaxy with the history of star formation across the galactic disk. The steep decline could be the sign of an unusual episode in our galaxy's history - say, our home galaxy “swallowing” a smaller galaxy with gas that contained very few metals. That gas would later on have served as raw material for the formation of stars with fewer metals in the disk. It is also possible that our estimate for the extent of the stellar disk of the Milky Way is off, and that this error skews the comparison with other galaxies when it comes to how steep the decrease is.

Outlook

Maria Bergemann says, "The findings are very exciting! This is the first time that we can meaningfully compare the detailed chemical content of our galaxy with the measurements of many other galaxies. The results are important for the next generation of comprehensive studies of galaxy formation. Those studies will use data from upcoming large-scale observational programs targeting the Milky Way or targeting distant galaxies. Our research shows how to sensibly combine the two kinds of data set."

All in all, the research described here raises a number of interesting questions. With new surveys, and new studies that explore an "alien astronomer" perspective, we can hope to find answers, and to better understand our home galaxy's history in the process.

https://phys.org/news/2023-06-reconstructing-alien-astronomer-view-home.html

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Janus the White Dwarf

Janus the White Dwarf sounds like a character from Lord of the Rings, but Janus is the nickname given to an extraordinary star that has been closely studied recently. Janus was the roman god of transition, and is often depicted as having two faces. This unusual star also appears to have two faces: one mostly made of hydrogen and one mostly of helium. Hence the name is both appropriate and also convenient, because the official designation "ZTF J203349.8+322901.1" is not so memorable. A paper published in Nature in July reveals that it is an extraordinary object, an extreme example of a class of star new to astronomy.

We have been treated to some excellent monthly talks at VAS this year, and to appreciate this strange star brings together ideas from three of them: Elizabeth Cunningham (in June) talked about the lifecycle of stars from birth to death and beyond; Bryn Davis (in July) brought us a comprehensive introduction to variable stars; and Steve Broadbent (in February) told us about spectroscopy and how the spectra of stars can be analysed to show what elements they are made of.

The Janus star is a white dwarf, the remnants of a dying star of about the same mass as our Sun. But after using up most of its hydrogen, the structure changes to become a red giant. The huge distended atmosphere of a red giant eventually disperses leaving the still hot (but cooling) and very dense core. It would be the mass of our Sun but reduced to the size of the Earth!

Figure 1 - Left: an artist's impression of the two-faced star; Right: an artist's impression of a two-faced Roman god!

Figure 2
Ilaria Caiazzo

It is a variable star, with brightness that varies periodically from brightest to dimmest and back to brightest every 15 mins. White dwarf stars are very numerous – it is what will be left of most main sequence stars in the end – but in their dying days they are not very luminous. Therefore, to survey this class of star the Caltech astronomer **Ilaria Caiazzo** and her team used the Zwicky Transient Facility (that is the "ZTF" in the star's official name) at Mount Palomar Observatory in San Diego to discover it. Realising they had something unusual in their data, she did subsequent investigations with instruments in the Canary Islands and Hawaii.

It was the work in Hawaii, using a spectrometer at the W M Keck observatory, that clarified how the variations in brightness came about. But examining the spectral lines in the starlight when it was at its brightest, compared with the spectrum when it is at its dimmest, clearly shows the signatures of hydrogen in one and helium on the other. The shape of the light curve (over time) is consistent with one half of the star consisting of hydrogen and the other of helium, with the star rotating on its axis every 15 minutes presenting the two contrasting sides to the observer. While both sides are blue-hot, the structure of the helium side will have a grainy surface with darker cell boundaries, whereas the hydrogen side will be smoother. This gives enough difference to appear brighter and darker by turns.

These findings have now sparked research and theoretical exploration for how this strange structure might have come about. The best explanation – although still to be thoroughly tested and compared with other unusual white dwarf stars – is that a magnetic anomaly has separated the two elements. Usually, we would expect the heavier element, helium, to sink to the core leaving the lighter, hydrogen, as a concentric layer above it. This is a star in transition (hence the name) from hydrogen-burning to the later stage of helium-burning. In the churn and mass movement of charged plasma within a star, magnetic fields are forming and looping and twisting all the time, but somehow a stable state has been reached which stops (or delays) the usual mixing of elements.

Janus, the two-faced white dwarf, is a kind of object we have never seen before. And it is interesting that the observations were made with ground-based observatories: it is not just the space telescopes that are pushing the boundaries of astronomy. Through some extraordinary work and great technology, we now know about a new type of rotating variable star, another exotic creature in the astronomy zoo.

Photo credits

Fig 1 (left): Janus, the two-faced, blue-tinted dead cinder of a star, once resembled our sun. The white dwarf is about 1,300 light-years away in the constellation Cygnus. (Credit: K. Miller, Caltech/IPAC)

Fig 1 (right): From wikipedia "Janus" – Double herm. Marble, Roman copy after a Greek original. (By Marie-Lan Nguyen (2009), CC BY 3.0, *https://commons.wikimedia.org/w/index.php?curid=8962565*)

Fig 2: Ilaria Caiazzo's website ilariacaiazzo.com (*Ilaria Caiazzo – Astrophysicist*)

Source materials I used for this article:

An article in *The Guardian* by Hannah Devlin (19 July 2023) - *Two-faced star with helium and hydrogen sides baffles astronomers | Astronomy | The Guardian*

The abstract to the published paper in Nature: Caiazzo, I., Burdge, K.B., Tremblay, PE. et al. A rotating white dwarf shows different compositions on its opposite faces. Nature 620, 61–66 (2023). *https://doi.org/10.1038/s41586-023-06171-9*

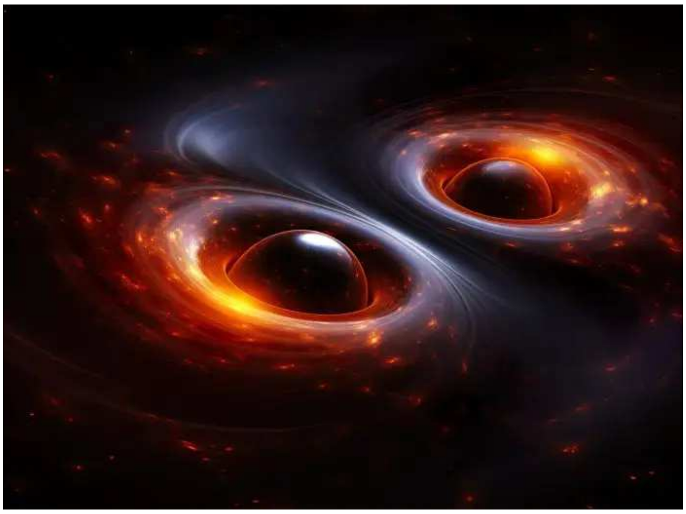
A *Caltech* news article by Whitney Calvin (19 July 2023)

You can even explore the data used in this discovery at *https://github.com/ilac/Janus*

I would also recommend Ilaria Caiazzo's engaging lectures about the hunt for extreme white dwarf stars, for example *Astronomical Observatory Tuesday Seminar 25 Oct 2022 4pm CEST, Ilaria Caiazzo (Caltech, US) - YouTube* (*https://www.youtube.com/watch?v=99nhpROYKVs*)

Prepared for New Zenith by Simon Gardner.

Louder Than Expected: Gravitational Waves From Merging Supermassive Black Holes "Heard" for First Time



Following 15 years of observing pulsars, the NANOGrav collaboration has detected gravitational waves stronger than ever before, likely produced by supermassive black hole pairs. This groundbreaking discovery presents the first evidence for the gravitational wave background, which is surprisingly louder than anticipated, possibly pointing to an abundance of supermassive black holes or alternative gravitational wave sources.

After 15 years of carefully observing stars called pulsars throughout our galaxy, the NANOGrav collaboration has "heard" the perpetual chorus of gravitational waves rippling through our universe.

Following 15 years of data collection in a galaxy-sized experiment, scientists have "heard" the perpetual chorus of gravitational waves rippling through our universe for the first time — and it's louder than expected.

The groundbreaking discovery was made by scientists with the North American Nanohertz Observatory for Gravitational Waves (NANOGrav) who closely observed stars called pulsars that act as celestial metronomes. The newly detected gravitational waves — ripples in the fabric of space-time — are by far the most powerful ever measured: They carry roughly a million times as much energy as the one-off bursts of gravitational waves from black hole and neutron star mergers detected by experiments such as LIGO and Virgo.

Most of the gigantean gravitational waves are probably produced by pairs of supermassive black holes spiraling toward cataclysmic collisions throughout the cosmos, the NANOGrav scientists report in a series of new papers published today (June 29) in The Astrophysical Journal Letters.

"It's like a choir, with all these supermassive black hole pairs chiming in at different frequencies," says NANOGrav scientist Chiara Mingarelli, who worked on the new findings while an associate research scientist at the Flatiron Institute's Center for Computational Astrophysics (CCA) in New York City. "This is the first-ever evidence for the gravitational wave background. We've opened a new window of observation on the universe."

The existence and composition of the gravitational wave background — long theorized but never before heard — presents a treasure trove of new insights into long-standing questions, from the fate of supermassive black hole pairs to the frequency of galaxy mergers.

Pulsars are fast-spinning neutron stars that emit narrow, sweeping beams of radio waves. Credit: NASA's Goddard Space Flight Center

For now, NANOGrav can only measure the overall gravitational wave background rather than radiation from the individual "singers." But even that brought surprises.

"The gravitational wave background is about twice as loud as what I expected," says Mingarelli, now an assistant professor at Yale University. "It's really at the upper end of what our models can create from just supermassive black holes." The deafening volume may result from experimental limitations or heavier and more abundant supermassive black holes. But there's also the possibility that something else is generating powerful gravitational waves, Mingarelli says, such as mechanisms predicted by string theory or alternative explanations of the universe's birth. "What's next is everything," she says. "This is just the beginning."

A Galaxy-Wide Experiment

Getting to this point was a years-long challenge for the NANOGrav team. The gravitational waves they hunted are different from anything previously measured. Unlike the high-frequency waves detected by earthbound instruments such as LIGO and Virgo, the gravitational wave background is made up of ultra-low-frequency waves. A single rise and fall of one of the waves could take years or even decades to pass by. Since gravitational waves travel at the speed of light, a single wavelength could be tens of light-years long.

No experiment on Earth could ever detect such colossal waves, so the NANOGrav team instead looked to the stars. They closely observed pulsars, the ultra-dense remnants of massive stars that went supernova. Pulsars act like stellar lighthouses, shooting beams of radio waves from their magnetic poles. As the pulsars rapidly spin (sometimes hundreds of times a second), those beams sweep across the sky, appearing from our vantage point on Earth as rhythmic pulses of radio waves.

The Very Large Array in New Mexico gathered data that contributed to the detection of the universe's gravitational wave background. Credit: NRAO/AUI/NS

The pulses arrive on Earth like a perfectly timed metronome. The timing is so precise that when Jocelyn Bell measured the first pulsar radio waves in 1967, astronomers thought they might be signals from an alien civilization.

As a gravitational wave passes between us and a pulsar, it throws off the radio wave timing. That's because, as Albert Einstein predicted, gravitational waves stretch and compress space as they ripple through the cosmos, changing how far the radio waves have to travel.

For 15 years, NANOGrav scientists from the United States and Canada closely timed the radio wave pulses from dozens of millisecond pulsars in our galaxy using the Arecibo Observatory in Puerto Rico, the Green Bank Telescope in West Virginia and the Very Large Array in New Mexico. The new findings are the result of a detailed analysis of an array of 67 pulsars.

"Pulsars are actually very faint radio sources, so we require thousands of hours a year on the world's largest telescopes to carry out this experiment," says Maura McLaughlin of West Virginia University, co-director of the

NANOGrav Physics Frontiers Center. “These results are made possible through the National Science Foundation’s (NSF’s) continued commitment to these exceptionally sensitive radio observatories.”

Detecting the Background

In 2020, with just over 12 years of data, NANOGrav scientists began to see hints of a signal, an extra “hum” common to the timing behavior of all pulsars in the array. Now, three years of additional observations later, they have accumulated concrete evidence for the existence of the gravitational wave background.

“Now that we have evidence for gravitational waves, the next step is to use our observations to study the sources producing this hum,” says Sarah Vigeland of the University of Wisconsin-Milwaukee, chair of the NANOGrav detection working group.

The likeliest sources of the gravitational wave background are pairs of supermassive black holes caught in a death spiral. Those black holes are truly colossal, containing billions of suns’ worth of mass. Nearly all galaxies, including our own Milky Way, have at least one of the behemoths at their core. When two galaxies merge, their supermassive black holes can meet up and begin orbiting one another. Over time, their orbits tighten as gas and stars pass between the black holes and steal energy.

Eventually, the supermassive black holes get so close that the energy theft stops. Some theoretical studies have argued for decades that the black holes then stall indefinitely when they’re around 1 parsec apart (roughly three light-years). This close-but-no-cigar theory became known as the final parsec problem. In this scenario, only rare groups of three or more supermassive black holes result in mergers.

Supermassive black hole pairs could have a trick up their sleeves, though. They could emit energy as powerful gravitational waves as they orbit one another until eventually they collide in a cataclysmic finale. “Once the two black holes get close enough to be seen by pulsar timing arrays, nothing can stop them from merging within just a few million years,” says Luke Kelley of the University of California, Berkeley, chair of NANOGrav’s astrophysics group.

The existence of the gravitational wave background found by NANOGrav seems to back up this prediction, potentially putting the final parsec problem to rest.

Since supermassive black hole pairs form due to galaxy mergers, the abundance of their gravitational waves will help cosmologists estimate how frequently galaxies have collided throughout the universe’s history. Mingarelli, postdoctoral researcher Deborah C. Good of the CCA and the University of Connecticut, and their colleagues studied the intensity of the gravitational wave background. They estimate that hundreds of thousands or maybe even a million or more supermassive black hole binaries inhabit the universe.

Alternative Sources

Not all the gravitational waves detected by NANOGrav are necessarily from supermassive black hole pairs, though. Other theoretical proposals also predict waves in the ultra-low-frequency range. String theory, for instance, predicts that one-dimensional defects called cosmic strings may have formed in the early universe. These strings could dissipate energy by emitting gravitational waves. Another proposal suggests that the universe didn’t start with the Big Bang but with a Big Bounce as a precursor universe collapsed in on itself before expanding back outward. In such an origin story, gravitational waves from the incident would still be rippling through space-time.

There’s also a chance that pulsars aren’t the perfect gravitational wave detectors scientists think they are, and that they instead might have some unknown variability that’s skewing NANOGrav’s results. “We can’t walk over to the pulsars and turn them on and off again to see if there’s a bug,” Mingarelli says.

The NANOGrav team hopes to explore all the potential contributors to the newfound gravitational wave background as they continue monitoring the pulsars. The group plans to break down the background based on the waves’ frequency and origin in the sky.

An International Effort

Luckily, the NANOGrav team isn’t alone in its quest. Several papers released today by collaborations using telescopes in Europe, India, China and Australia report hints of the same gravitational wave background signal in their data. Through the International Pulsar Timing Array consortium, the individual groups are pooling their data to better characterize the signal and identify its sources.

“Our combined data will be much more powerful,” says Stephen Taylor of Vanderbilt University, who co-led the new research and currently chairs the NANOGrav collaboration. “We’re excited to discover what secrets they will reveal about our universe.”

From: https://scitechdaily.com/louder-than-expected-gravitational-waves-from-merging-supermassive-black-holes-heard-for-first-time/

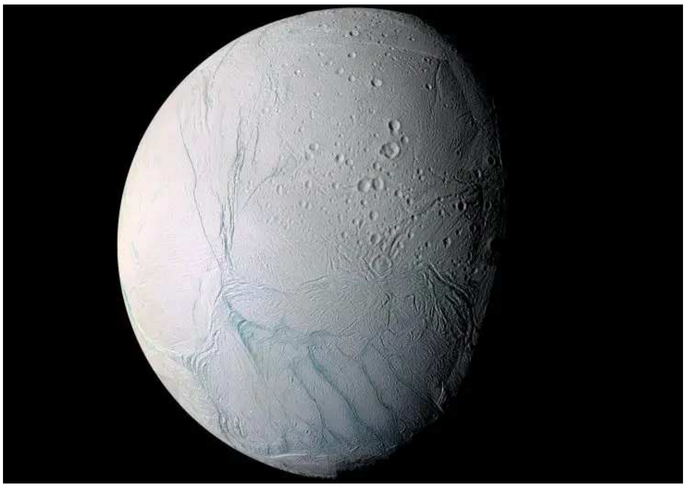
Saturn's Icy Moon Enceladus: Study Proves Existence of Key Element for Life in the Outer Solar System

Saturn's moon Enceladus with plume. Through cracks in the ice crust of Enceladus, icy cryovolcanic jets erupt into space. The ice grains are generated from the global ocean under the ice layer that is a few kilometers thick. Credit: NASA/JPL-Caltech/SSI/Kevin M. Gill

The search for extraterrestrial life in our solar system has just taken a giant leap forward. A team of researchers led by Professor Frank Postberg, a planetary scientist at Freie Universität Berlin, has discovered new evidence that the subsurface ocean of Saturn's icy moon Enceladus contains a key building block for life. The international research team used data from the Cassini space mission to detect phosphorus in the form of phosphates in ice particles – originating from the moon's ice-covered global ocean – that had been ejected into space by the moon's cryo-volcanic plume. The study was published in the scientific journal Nature on Wednesday, June 14, 2023.

"Previous geochemical models were divided on the question of whether Enceladus' ocean contains significant quantities of phosphates at all," says Professor Postberg. "These Cassini measurements leave no doubt that substantial quantities of this essential substance are present in the ocean water." Phosphorus in the form of phosphates is vital for all life on Earth. It is essential for the creation of DNA and RNA, cell membranes, and ATP (the universal energy carrier in cells) for example. Life as we know it would simply not exist without phosphates.

"By determining such high phosphate concentrations readily available in Enceladus' ocean, we have now satisfied what is generally considered one of the strictest requirements in establishing whether celestial bodies are habitable," says early-career researcher Dr. Fabian Klenner, who has since relocated to Seattle where he continues to conduct research at the University of Washington. "The next step is clear – we need to go back to Enceladus to see if the habitable ocean is actually inhabited," adds Dr. Nozair Khawaja, a planetary scientist originally from Pakistan who is now firmly established at Freie Universität Berlin.

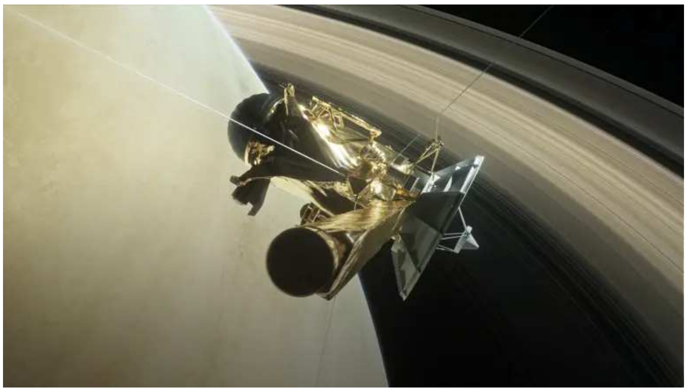


During a 2005 flyby, NASA's Cassini spacecraft took high-resolution images of Enceladus that were combined into this mosaic, which shows the long fissures at the moon's south pole that allow water from the subsurface ocean to escape into space. Credit: NASA/JPL/Space Science Institute

A few years ago the Cassini-Huygens spacecraft, which was deployed by NASA and ESA into Saturn's orbit between 2004 and 2017, discovered Enceladus' subsurface liquid water ocean and analyzed samples in a plume of ice grains and gases that erupt into space from cracks in the moon's icy crust. In previous studies, Postberg's team had already determined that Enceladus harbors a "soda ocean" (rich in dissolved carbonates) and contains a vast variety of reactive and sometimes complex organic compounds. They also found indications of hydrothermal environments on the seafloor.

However, the research team at Freie Universität Berlin only recently discovered unmistakable signatures of phosphates in the data. What is crucial for bioavailability is that the phosphates are not trapped in rocky minerals but dissolved in the ocean as salt. The phosphate concentrations were determined to be at least 100 to 1,000 times higher than in Earth's oceans. To investigate how Enceladus could maintain such high phosphate concentrations in its ocean, lab experiments were conducted in cooperation with a team of researchers located in Japan (led by Professor Yasuhito Sekine) and the US (Dr. Christopher R. Glein).

"Our geochemical experiments and modeling demonstrate that such high phosphate concentrations result from enhanced phosphate mineral solubility, for which the specific conditions exist not only on Enceladus, but more generally throughout the entire outer solar system," explains Postberg. "That's great news for a number of ocean worlds outside of Jupiter."



Artist's depiction of NASA's Cassini during its 2017 "grand finale," in which the spacecraft dove between Saturn and its rings multiple times before purposefully crashing into the planet's atmosphere. Credit: NASA/JPL-Caltech

One of the most profound discoveries in planetary science over the past twenty-five years is that worlds with oceans beneath a surface layer of ice are common in our solar system. They contain considerably more water than all of the oceans on Earth combined and include the icy moons of Jupiter and Saturn like Ganymede, Titan, and Enceladus, as well as even more distant celestial bodies like Pluto. Planets with surface oceans like Earth must reside within a narrow range of distances from their host stars (in what is known as the "habitable zone") to maintain temperatures at which water neither evaporates nor freezes. Worlds with an interior ocean like Enceladus, however, can occur over a much wider range of distances, greatly expanding the number of habitable worlds likely to exist across the galaxy.

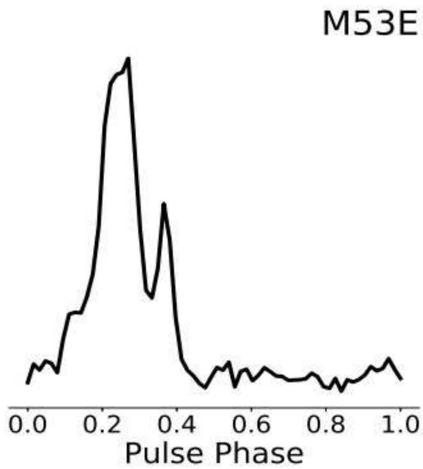
From: https://scitechdaily.com/

New Millisecond Pulsar Detected

Using the Five-hundred-meter Aperture Spherical radio Telescope (FAST), a team of Chinese astronomers has detected a new millisecond pulsar in the globular cluster M53.

Pulsars are highly magnetized, rotating neutron stars emitting a beam of electromagnetic radiation. The most rapidly rotating pulsars, with rotation periods below 30 milliseconds, are known as millisecond pulsars (MSPs). Astronomers assume that they are formed in binary systems when the initially more massive component turns into a neutron star that is then spun up due to accretion of matter from the secondary star.

Globular clusters (GCs) are collections of tightly bound stars orbiting galaxies. They have extraordinarily dense stellar environments, making them excellent places to form X-ray binary systems of millisecond pulsars.



Integrated pulse profile of the newfound pulsar PSR J1312+1810E (M53E). Credit: Lian et al., 2023

Located some 58,350 light years away, Messier 53 is so far the most distant GC with known pulsars. The cluster is about 12.67 billion years old, has a mass of approximately 826,000 solar masses, and a metallicity of -2.1, which makes it one of the most metal-poor GCs in the Milky Way. To date, four pulsars have been detected in Messier 53, and three of them turned out to be MSPs.

Now, a group of astronomers led by Yujie Lian of the Beijing Normal University in China, reports the discovery of another MSP in this cluster. Detection was made using the center beam of the FAST 19-beam L-band receiver.

"The tracking observation of M53 was initiated on November 30, 2019, as the pilot survey for the FAST GC pulsar survey and SP2 project 4 (Pan et al. 2021)," the researchers wrote in the paper.

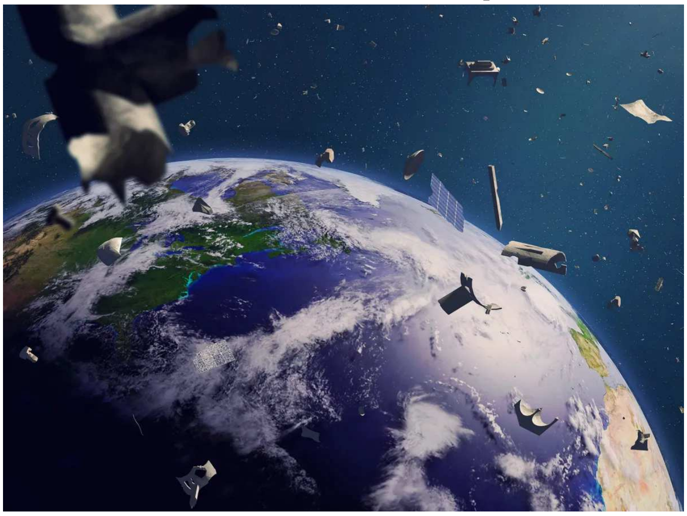
The newfound pulsar received designation PSR J1312+1810E (or M53E). It has a spin period of about 3.97 milliseconds and dispersion measure of approximately 25.88 pc/cm3. The orbital period of M53E was found to be 2.43 days.

The companion object in the system is most likely a white dwarf with an estimated mass of at least 0.18 solar masses. The surface magnetic field strength of M53E was measured to be not greater than 140 million Gauss and the pulsar's characteristic age was calculated to be more than 13 billion years.

Besides the detection of M53E, FAST observations also allowed Lian's team to investigate the three other MSPs in the M53 cluster. They found that one of them is an isolated pulsar, while the other two are binary systems with white dwarf companions slightly more massive than the one in M53E. All in all, the results show characteristics of this pulsar population are similar to the population of MSPs in the Milky Way's disk.

From: https://phys.org/

AI Battles the Bane of Space Junk



Photos from low Earth orbit (LEO) are often strikingly beautiful. But what they typically fail to capture is the tens of thousands of debris pieces, or "space junk," that orbit around Earth's face like hungry mosquitoes - and threaten to hit satellites and other orbiting assets with enough force to be destructive. Such pieces of space junk - only a fraction of which space agencies like NASA and ESA can track with ground-based telescopes - are only going to multiply as mega-constellations like Starlink or OneWeb enter LEO.

A growing number of planners and researchers are concerned about whether further crowding could lead to a higher risk of catastrophic collisions that knock out communications satellites or even one day send fiery debris back to Earth. To better anticipate and avoid these situations, some are turning to computer simulations and artificial intelligence to better see what humans cannot.

Researchers are, using machine learning to investigate methods of debris removal and reuse. In a paper presented earlier this year at the European Space Agency's second NEO and Debris Detection Conference in Darmstadt, Germany, Fabrizio Piergentili and colleagues presented results of their evolutionary "genetic" algorithm to monitor the rotational motion of space debris.

"Objects that move too fast cannot be easily captured," Piergentili says. "So, if I have one mission to go into orbit, it is better to identify objects that move slowly, so they are easier to catch."

In addition to developing neural networks to anticipate these collisions, which can take time and considerable resources to train and test, other researchers like Lt. Col. Robert Bettinger are turning to computer simulations to anticipate satellite behavior.

In a paper published earlier this year, Bettinger, an assistant professor of aerospace engineering at the Air Force Institute of Technology, and coauthor Joseph Canoy investigated how likely that the breakup of a single satellite within the orbit of a mega-constellation would lead to a catastrophic collision either in LEO or medium Earth orbit (MEO).

To make predictions about these future events, Bettinger and Canoy used a combination of historic statistics and predictive modeling through a Monte Carlo simulation. They were then able to determine that mega-constellations in low Earth orbit have a risk of catastrophic conjunctions 14x as many as satellites in MEO. That said, this finding isn't completely surprising, Bettinger admits, as LEO has a smaller spatial volume with more objects going at higher velocities than in MEO.

Federica Massimi is a Ph.D. student at Roma Tre University and first author on a paper published last December in Sensors that explores the way deep learning can be used to support debris detection in LEO. In a simulated environment, Massimi and coauthors demonstrated how a neural network can be trained on reams of radar and optical data from ground telescopes to make it easier for space debris to pop out of the noise.

Beyond tracking debris that already exists in space, Massimi says she believes these methods will play a role in the entire life cycle of satellites launched as a part of mega-constellations. Increasingly, she says, spacefaring companies and organizations will need to optimize satellite distribution or assist with orbit management to avoid debris collisions that could cause cascading damage.

Yet, while introducing intelligent algorithms and simulations to the problem of space debris may seem like a no-brainer, Moriba Jah, associate professor of aerospace engineering at the University of Texas at Austin, says the world should be wary of relying too heavily on AI-based answers in a space that still has so many unknowns.

"These algorithms assume that tomorrow looks like today," Jah says. "So, if the version of today that you feed it is limited, the prediction of tomorrow is also limited." Jah also says that there are a number of other unknowns in the space environment too, such as atmospheric density, that make predicting debris behavior even more difficult.

"That's still a gaping hole, scientifically," Jah says. AI, he adds, therefore "has limited use given those known gaps."

These concerns are something that Massimi considers in her work as well. Crucially, she says AI models need updating "with real-time information, including new debris detections and orbital changes." This way, "algorithms can better adapt to the changing spatial environment." If so, researchers hope AI can help keep the pictures from low Earth orbit as striking as ever, while keeping the orbits themselves much less so.

From: https://spectrum.ieee.org/

Gauging the Strength of Ancient and Active Rivers Beyond Earth

Rivers have flowed on two other worlds in the solar system besides Earth: Mars, where dry tracks and craters are all that's left of ancient rivers and lakes, and Titan, Saturn's largest moon, where rivers of liquid methane still flow today.

A new technique developed by MIT geologists allows scientists to see how intensely rivers used to flow on Mars, and how they currently flow on Titan. The method uses satellite observations to estimate the rate at which rivers move fluid and sediment downstream.

Applying their new technique, the MIT team calculated how fast and deep rivers were in certain regions on Mars more than 1 billion years ago. They also made similar estimates for currently active rivers on Titan, even though the moon's thick atmosphere and distance from Earth make it harder to explore, with far fewer available images of its surface than those of Mars.

"What's exciting about Titan is that it's active. With this technique, we have a method to make real predictions for a place where we won't get more data for a long time," says Taylor Perron, the Cecil and Ida Green Professor in MIT's Department of Earth, Atmospheric and Planetary Sciences (EAPS). "And on Mars, it gives us a time machine, to take the rivers that are dead now and get a sense of what they were like when they were actively flowing."

Perron and his colleagues have published their results today in the Proceedings of the National Academy of Sciences. Perron's MIT co-authors are first author Samuel Birch, Paul Corlies, and Jason Soderblom, with Rose Palermo and Andrew Ashton of the Woods Hole Oceanographic Institution (WHOI), Gary Parker of the University of Illinois at Urbana-Champaign, and collaborators from the University of California at Los Angeles, Yale University, and Cornell University.

River math

The team's study grew out of Perron and Birch's puzzlement over Titan's rivers. The images taken by NASA's Cassini spacecraft have shown a curious lack of fan-shaped deltas at the mouths of most of the moon's rivers, contrary to many rivers on Earth. Could it be that Titan's rivers don't carry enough flow or sediment to build deltas?

The group built on the work of co-author Gary Parker, who in the 2000s developed a series of mathematical equations to describe river flow on Earth. Parker had studied measurements of rivers taken directly in the field by others. From these data, he found there were certain universal relationships between a river's physical dimensions -- its width, depth, and slope -- and the rate at which it flowed. He drew up equations to describe these relationships mathematically, accounting for other variables such as the gravitational field acting on the river, and the size and density of the sediment being pushed along a river's bed.

"This means that rivers with different gravity and materials should follow similar relationships," Perron says. "That opened up a possibility to apply this to other planets too."

Getting a glimpse

On Earth, geologists can make field measurements of a river's width, slope, and average sediment size, all of which can be fed into Parker's equations to accurately predict a river's flow rate, or how much water and sediment it can move downstream. But for rivers on other planets, measurements are more limited, and largely based on images and elevation measurements collected by remote satellites. For Mars, multiple orbiters have taken high-resolution images of the planet. For Titan, views are few and far between.

Birch realized that any estimate of river flow on Mars or Titan would have to be based on the few characteristics that can be measured from remote images and topography -- namely, a river's width and slope. With some algebraic tinkering, he adapted Parker's equations to work only with width and slope inputs. He then assembled data from 491 rivers on Earth, tested the modified equations on these rivers, and found that the predictions based solely on each river's width and slope were accurate.

Then, he applied the equations to Mars, and specifically, to the ancient rivers leading into Gale and Jezero Craters, both of which are thought to have been water-filled lakes billions of years ago. To predict the flow rate of each river, he plugged into the equations Mars' gravity, and estimates of each river's width and slope, based on images and elevation measurements taken by orbiting satellites.

From their predictions of flow rate, the team found that rivers likely flowed for at least 100,000 years at Gale Crater and at least 1 million years at Jezero Crater -- long enough to have possibly supported life. They were also able to compare their predictions of the average size of sediment on each river's bed with actual field measurements of Martian grains near each river, taken by NASA's Curiosity and Perseverance rovers. These few field measurements allowed the team to check that their equations, applied on Mars, were accurate.

The team then took their approach to Titan. They zeroed in on two locations where river slopes can be measured, including a river that flows into a lake the size of Lake Ontario. This river appears to form a delta as it feeds into the lake. However, the delta is one of only a few thought to exist on the moon -- nearly every viewable river flowing into a lake mysteriously lacks a delta. The team also applied their method to one of these other delta-less rivers.

They calculated both rivers' flow and found that they may be comparable to some of the biggest rivers on Earth, with deltas estimated to have a flow rate as large as the Mississippi. Both rivers should move enough sediment to build up deltas. Yet, most rivers on Titan lack the fan-shaped deposits. Something else must be at work to explain this lack of river deposits.

In another finding, the team calculated that rivers on Titan should be wider and have a gentler slope than rivers carrying the same flow on Earth or Mars. "Titan is the most Earth-like place," Birch says. "We've only gotten a glimpse of it. There's so much more that we know is down there, and this remote technique is pushing us a little closer."

From: https://www.sciencedaily.com/

Universe is Older Than Thought?

Our universe could be twice as old as current estimates, according to a new study that challenges the dominant cosmological model and sheds new light on the so-called "impossible early galaxy problem."

"Our newly-devised model stretches the galaxy formation time by a several billion years, making the universe 26.7 billion years old, and not 13.7 as previously estimated," says author Rajendra Gupta, adjunct professor of physics in the at the University of Ottawa.

For years, astronomers and physicists have calculated the age of our universe by measuring the time elapsed since the Big Bang and by studying the oldest stars based on the redshift of light coming from distant galaxies. In 2021, thanks to new techniques and advances in technology, the age of our universe was thus estimated at 13.797 billion years using the Lambda-CDM concordance model.

However, many scientists have been puzzled by the existence of stars like the Methuselah that appear to be older than the estimated age of our universe and by the discovery of early galaxies in an advanced state of evolution made possible by the James Webb Space Telescope. These galaxies, existing a mere 300 million years or so after the Big Bang, appear to have a level of maturity and mass typically associated with billions of years of cosmic evolution. Furthermore, they're surprisingly small in size, adding another layer of mystery to the equation.

Zwicky's tired light theory proposes that the redshift of light from distant galaxies is due to the gradual loss of energy by photons over vast cosmic distances. However, it was seen to conflict with observations. Yet Gupta found that "by allowing this theory to coexist with the expanding universe, it becomes possible to reinterpret the redshift as a hybrid phenomenon, rather than purely due to expansion."

In addition to Zwicky's tired light theory, Gupta introduces the idea of evolving "coupling constants," as hypothesized by Paul Dirac. Coupling constants are fundamental physical constants that govern the interactions between particles. According to Dirac, these constants might have varied over time. By allowing them to evolve, the timeframe for the formation of early galaxies observed by the Webb telescope at high redshifts can be extended from a few hundred million years to several billion years. This provides a more feasible explanation for the advanced level of development and mass observed in these ancient galaxies.

Moreover, Gupta suggests that the traditional interpretation of the "cosmological constant," which represents dark energy responsible for the accelerating expansion of the universe, needs revision. Instead, he proposes a constant that accounts for the evolution of the coupling constants. This modification in the cosmological model helps address the puzzle of small galaxy sizes observed in the early universe, allowing for more accurate observations.

From: https://www.sciencedaily.com/

Unintended Satellite Emission May Harm Radio Astronomy

Satellites' leakage radiation, now detected for the first time, may become a major problem for radio astronomy, as "megaconstellations" keep on growing.

Astronomical radio sources, while intrinsically intense, are also far away. What little of their signal reaches Earth is therefore really faint: A single mobile phone on the surface of the Moon would outshine all but the very brightest of them.

Communication signals of Earth-orbiting satellites are much stronger but are by regulation limited to certain wavelengths. They're also known to radio astronomers, who can filter them out. However, leakage radiation may result in artificial signals at unintended wavelengths. Leakage typically comes from human activity on the ground, but with the number of satellites literally skyrocketing, astronomers are becoming concerned about the effect from space. Now, a team has announced the first detection of this electromagnetic interference from satellites.

"Leakage radiation from artificial satellites as a possible interference first appeared in our minds only about two years ago," recalls Benjamin Winkel (Max-Planck Institute for Radio Astronomy, Germany, and Committee on Radio Astronomy Frequencies, France). "Back then, nobody knew how strong such an effect would be, and if this was more than just a theoretical problem."

So Winkel, together with a couple of colleagues from other institutions associated with the Square Kilometre Array Observatory (SKAO), decided to have a look. They used the core antennas of the Low-Frequency Array (LOFAR) in The Netherlands to look for signals from satellites in SpaceX's Starlink constellation. There were about 2,100 Starlinks in orbit when these data were taken; now there are more than 4,000.

What they found did not quell their fears. Of a total of 68 observed satellites, 47 were detected at frequencies between 110 and 188 MHz. This leakage radiation is well below the 10.7 to 12.7 GHz radio frequencies used for the downlink communication signals. Federico Di Vruno (SKAO and the Committee on Radio Astronomy Frequencies, France), Winkel, and their colleagues have published these results in Astronomy & Astrophysics.

Unintended radiation isn't exactly a surprise. "Every electric device generates leakage radiation," explains team member Gyula Józsa (also at Max Planck Institute for Radio Astronomy, Germany, and the Committee on Radio Astronomy Frequencies, France). "There is nothing you can do to prevent this, except to influence the strength of those signals."

Indeed, every gadget in your room that uses electricity, every circuit in your computer or phone, works as a tiny antenna, emitting some extra electromagnetic radiation. Manufacturers take care to ensure that this radiation doesn't interfere with other devices (or even with the device itself), but there is no reasonable way to eliminate it altogether.

The same is true for electronics in orbit. "Compared to communication signals, what satellites emit as leakage radiation is typically 1 million times weaker," Winkel explains. "However, for us radio astronomers, this is still strong enough; it's brighter than most of the astronomical sources we're observing."

When looking at the Starlink satellites, the team was able to follow their radio signals as they traversed the sky, showing that most of the radiation came from the satellites themselves, rather than reflections of other radio sources. (One specific frequency originated from a strong space-surveillance radar located in France, which reflected off of some of the satellites.)

The leaked signals the team detected are much stronger than any individual satellite would be allowed to be while still complying with regulatory thresholds. However, the regulations imposed by the International Telecommunication Union (ITU) only apply to intentional radio emissions.

The leakage problem is not limited to Starlink. Any operating satellite will emit some kind of leakage radiation. What's changing is the numbers — more satellites in the sky increases the chance that one will cross the relatively narrow field-of-view of radio telescopes on the ground.

"Usually, we just eliminate data that has been contaminated by a satellite from further processing," says Józsa. "The more this happens, the more observation time we lose." For time-dependent observations, this can mean losing critical information. For example, astronomers could lose detections of mysterious fast radio bursts (FRBs) - extremely strong radio emissions that last seconds at most.

Even more troubling may be weaker, unidentified signals that hide in the underlying noise, says Józsa, which might lead to erroneous results when typical methods for noise reduction are employed. Leakage radiation also becomes more prominent at lower frequencies, an expanding area for radio astronomy research. Observatories designed specifically to detect these frequencies, such as LOFAR, the Long Wavelength Array in New Mexico, or the low-frequency part of SKA to be built in Australia, are most likely to be affected.

Technical solutions can only mitigate - not solve - the problem. Any attempt to do so would require the help of satellite operators, but such cooperation would at this point be entirely voluntary. Leakage radiation, however strong it might be, doesn't violate any rules: "From the radio astronomer's perspective, unintentional electromagnetic radiation is currently not well regulated for satellites and spacecraft," the research team writes.

So far, the researchers have only obtained a one-hour "snapshot" of one type of satellite using one telescope. They found that the radio signal varied from satellite to satellite, with some not showing up at the observed frequencies at all. Follow-up observations within the coming year will give a more global picture of how much leakage radiation Starlink satellites generate.

But these first results already demonstrate the need for action, Józsa concludes: "We believe that the early recognition of this situation gives astronomy and large constellation operators an opportunity to work together on technical mitigations pro-actively, in parallel to the necessary discussions to develop suitable regulations."

From: https://skyandtelescope.org/

Robot Team on Lunar Exploration

On the Moon, there are raw materials that humanity could one day mine and use. Various space agencies, such as the European Space Agency (ESA), are already planning missions to better explore Earth's satellite and find minerals. This calls for appropriate exploration vehicles. Swiss researchers led by ETH Zurich are now pursuing the idea of sending not just one solitary rover on an exploration tour, but rather an entire team of vehicles and flying devices that complement each other.

The researchers equipped three ANYmal -- a type of legged robot developed at ETH -- with a range of measuring and analysis instruments that would potentially make them suitable exploration devices in the future. They tested these robots on various terrains in Switzerland and at the European Space Resources Innovation Centre (ESRIC) in Luxembourg, where, a few months ago, the Swiss team won a European competition for lunar exploration robots together with colleagues from Germany. The competition involved finding and identifying minerals on a test site modelled after the surface of the Moon. In the latest issue of the journal Science Robotics, the scientists describe how they go about exploring an unknown terrain using a team of robots.

Insurance against failure

"Using multiple robots has two advantages," explains Philip Arm, a doctoral student in the group led by ETH Professor Marco Hutter. "The individual robots can take on specialised tasks and perform them simultaneously. Moreover, thanks to its redundancy, a robot team is able to compensate for a teammate's failure." Redundancy in this case means that important measuring equipment is installed on several robots. In other words, redundancy and specialisation are opposing goals. "Getting the benefits of both is a matter of finding the right balance," Arm says.

The researchers at ETH Zurich and the Universities of Basel, Bern and Zurich solved this problem by equipping two of the legged robots as specialists. One robot was programmed to be particularly good at mapping the terrain and classifying the geology. It used a laser scanner and several cameras -- some of them capable of spectral analysis -- to gather initial clues about the mineral composition of the rock. The other specialist robot was taught to precisely identify rocks using a Raman spectrometer and a microscopy camera.

The third robot was a generalist: it was able to both map the terrain and identify rocks, which meant that it had a broader range of tasks than the specialists. However, its equipment meant that it could perform these tasks with less precision. "This makes it possible to complete the mission should any one of the robots malfunction," Arm says.

Combination is key

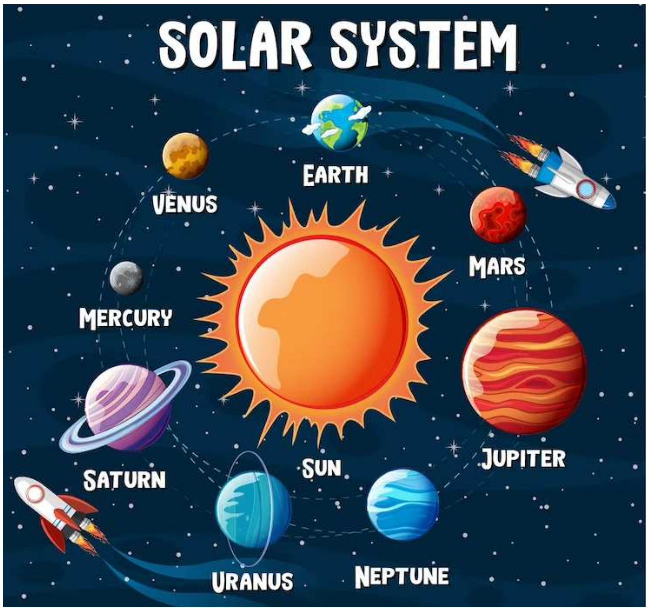
At the ESRIC and ESA Space Resources Challenge, the jury was particularly impressed that the researchers had built redundancy into their exploration system to make it resilient to potential failures. As a prize, the Swiss scientists and their colleagues from the FZI Research Center for Information Technology in Karlsruhe, were awarded a one-year research contract to further develop this technology. In addition to legged robots, this work will also involve robots with wheels, building on the FZI researchers' experience with such robots.

"Legged robots like our ANYmal cope well in rocky and steep terrain, for example when it comes to climbing down into a crater," explains Hendrik Kolvenbach, a senior scientist in Professor Hutter's group. Robots with wheels are at a disadvantage in these kinds of conditions, but they can move faster on less challenging terrain. For a future mission, it would therefore make sense to combine robots that differ in terms of their mode of locomotion. Flying robots could also be added to the team.

The researchers also plan to make the robots more autonomous. Presently, all data from the robots flows into a control centre, where an operator assigns tasks to the individual robots. In the future, semi-autonomous robots could directly assign certain tasks to each other, with control and intervention options for the operator.

Video: *https://youtu.be/bqwbQzVrzkQ*

From: https://www.sciencedaily.com/



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Ceiling-Mounted Orrery Is An Exercise In Simplicity

Ever since humans figured out that planets move along predetermined paths in the heavens, they have tried to make models that can accurately predict their motion. Watchmakers and astronomers worked together to create orreries: mechanical contraptions that illustrate the positions of all planets and the way they move over time through complex gear systems. [Illusionmanager] continues the orrery tradition but uses a different approach: he built a beautiful ceiling-mounted model of our Solar System without a gearing system.

The mechanism that makes his Solar System tick is deceptively simple. All planets can move freely along their orbit's axis except Mercury, which is moved along its orbit by a motor hidden inside the Sun. Once Mercury has completed a full revolution, a pin attached to its arm will begin pushing Venus along with it. After Venus has completed a full circle, its own pin will pick up Earth, and so on all the way to Neptune. Neptune is then advanced to its correct location as reported by NASA, after which Mercury's motion is reversed and the whole procedure is repeated in the opposite direction to position Uranus.

Cycling through the entire Solar System in this way takes a long time, which is why the planets' positions are only updated once a day at midnight. An ESP32, also hidden inside the Sun, connects to the internet to retrieve the correct positions for the day and drives the motor. The planet models, sourced from a museum shop, are hanging from thin aluminium tubes attached to wooden mounts made with a desktop CNC machine.

[Illusionmanager] made a detailed *Instructables page* showing the process of making a miniature version of the mechanism using just laser-cut wooden parts, as an update to a version we featured earlier. We really like the simplicity of this design, which stands in stark contrast to the huge gear trains used in more traditional orreries.

More + Movie: https://hackaday.com/2023/09/09/ceiling-mounted-orrery-is-an-excercise-in-simplicity/

Webb Space Telescope Reveals Dramatic Close-up of 50 Baby Stars

The first anniversary image released Wednesday, July 12, 2023, by Space Telescope Science Institute Office of Public Outreach, shows NASA's James Webb Space Telescope displaying a star birth like it's never been seen before, full of detailed, impressionistic texture. The subject is the Rho Ophiuchi cloud complex, the closest star-forming region to Earth. Credit: NASA, ESA, CSA, STScI, Klaus Pon via AP

The Webb Space Telescope is marking one year of cosmic photographs with one of its best yet: the dramatic close-up of dozens of stars at the moment of birth.

NASA unveiled the latest snapshot Wednesday, revealing 50 baby stars in a cloud complex 390 light-years away. A light-year is nearly 6 trillion miles (9.7 trillion kilometers).

The region is relatively small and quiet yet full of illuminated gases, jets of hydrogen and even dense cocoons of dust with the delicate beginnings of even more stars.

All of the young stars appear to be no bigger than our sun. Scientists said the breathtaking shot provides the best clarity yet of this brief phase of a star's life.

"It's like a glimpse of what our own system would have looked like billions of years ago when it was forming," NASA program scientist Eric Smith told The Associated Press.

Smith pointed out that the starlight visible in the image actually left there 390 years ago. On Earth in 1633, Italian astronomer Galileo Galilei went on trial in Rome for saying that the Earth revolved around the sun. The Vatican in 1992 acknowledged Galileo was wronged.

This cloud complex, known as Rho Ophiuchi, is the closest star-forming region to Earth and is found in the sky near the border of the constellations Ophiuchus and Scorpius, the serpent-bearer and scorpion. With no stars in the foreground of the photo, NASA noted, the details stand out all the more. Some of the stars display shadows indicating possible planets in the making, according to NASA.

It "presents star birth as an impressionistic masterpiece," NASA Administrator Bill Nelson said in a tweet.

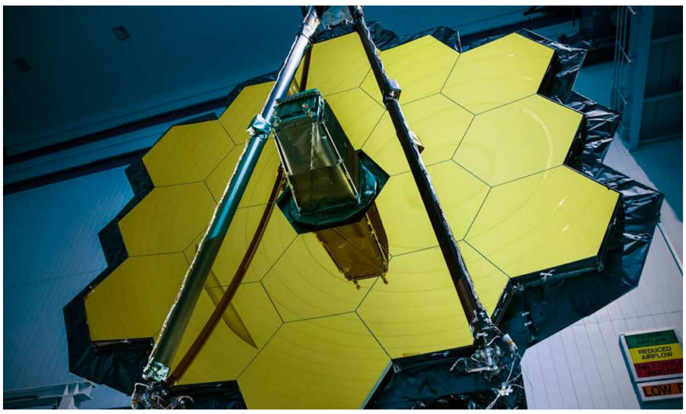
Webb - the largest and most powerful astronomical observatory ever launched into space - has been churning out cosmic beauty shots for the past year. The first pictures from the $10 billion infrared telescope were unveiled last July, six months after its liftoff from French Guiana.

It's considered the successor to the Hubble Space Telescope, orbiting Earth for 33 years. A joint NASA-European Space Agency effort, Webb scans the universe from a more distant perch, 1 million miles (1.6 million kilometers) away.

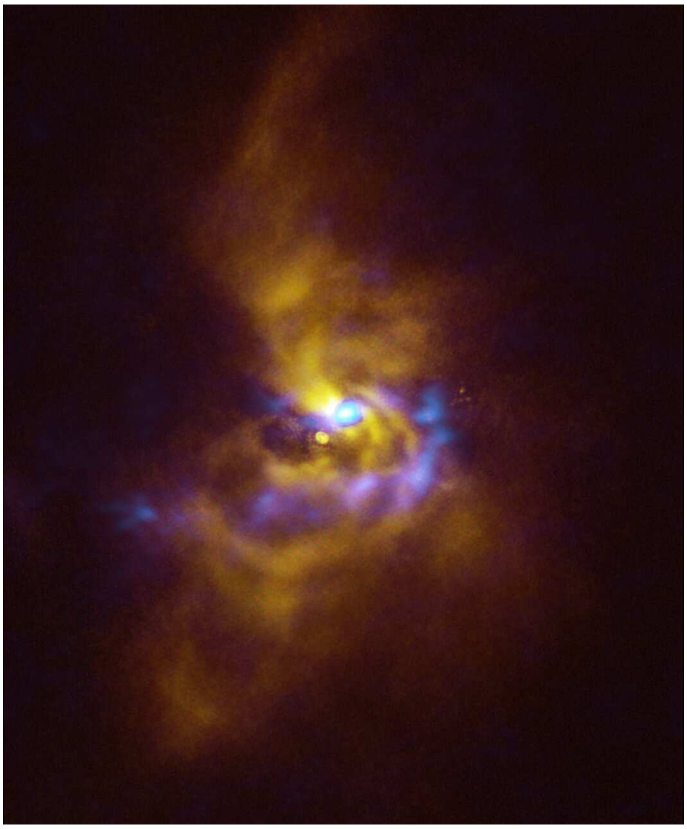
Still ahead for Webb: Astronomers hope to behold the earliest stars and galaxies of the universe while scouring the cosmos for any hints of life on planets outside our solar system.

"We haven't found one of them yet," Smith said. "But we're still only one year into the mission."

From: https://phys.org/



New Image Reveals Secrets of Planet Birth



At the center of this image is the young star V960 Mon, located over 5000 light-years away in the constellation Monoceros. Dusty material with potential to form planets surrounds the star.
Credit: ESO/ALMA (ESO/NAOJ/NRAO)/Weber et al.

A spectacular new image released today by the European Southern Observatory gives us clues about how planets as massive as Jupiter could form. Using ESO's Very Large Telescope (VLT) and the Atacama Large Millimeter/submillimeter Array (ALMA), researchers have detected large dusty clumps, close to a young star, that could collapse to create giant planets.

“This discovery is truly captivating as it marks the very first detection of clumps around a young star that have the potential to give rise to giant planets,” says Alice Zurlo, a researcher at the Universidad Diego Portales, Chile, involved in the observations.

Research describing the discovery is published in Astrophysical Journal Letters.

The work is based on a mesmerizing picture obtained with the Spectro-Polarimetric High-contrast Exoplanet REsearch (SPHERE) instrument on ESO's VLT that features fascinating detail of the material around the star V960 Mon. This young star is located over 5000 light-years away in the constellation Monoceros and attracted astronomers' attention when it suddenly increased its brightness more than twenty times in 2014. SPHERE observations taken shortly after the onset of this brightness “outburst” revealed that the material orbiting V960 Mon is assembling together in a series of intricate spiral arms extending over distances bigger than the entire solar system.

This finding then motivated astronomers to analyze archive observations of the same system made with ALMA, in which ESO is a partner. The VLT observations probe the surface of the dusty material around the star, while ALMA can peer deeper into its structure. “With ALMA, it became apparent that the spiral arms are undergoing fragmentation, resulting in the formation of clumps with masses akin to those of planets,” says Zurlo.

Astronomers believe that giant planets form either by “core accretion,” when dust grains come together, or by “gravitational instability,” when large fragments of the material around a star contract and collapse. While researchers have previously found evidence for the first of these scenarios, support for the latter has been scant.

“No one had ever seen a real observation of gravitational instability happening at planetary scales - until now,” says Philipp Weber, a researcher at the University of Santiago, Chile, who led the study.

“Our group has been searching for signs of how planets form for over ten years, and we couldn't be more thrilled about this incredible discovery,” says team-member Sebastián Pérez from the University of Santiago, Chile.

ESO instruments will help astronomers unveil more details of this captivating planetary system in the making, and ESO's Extremely Large Telescope (ELT) will play a key role. Currently under construction in Chile's Atacama Desert, the ELT will be able to observe the system in greater detail than ever before, collecting crucial information about it.

“The ELT will enable the exploration of the chemical complexity surrounding these clumps, helping us find out more about the composition of the material from which potential planets are forming,” concludes Weber.

From: https://phys.org/

Astronomers Capture Bizarre Extremely Warped Supernova

Astronomers have captured a bizarre image of a supernova, a powerful star explosion, with its light so distorted by the gravity of another galaxy that it appears as multiple images in the sky. This phenomenon, known as gravitational lensing, occurs when the gravity of a dense object warps and intensifies the light of an object behind it.

Dubbed "SN Zwicky," the supernova was initially observed by the Caltech-led Zwicky Transient Facility (ZTF), based at the Palomar Observatory near San Diego. The observation is part of the largest supernova survey currently underway.

"With ZTF, we have the unique ability to catch and classify supernovae in near real-time. We noticed that SN Zwicky was brighter than it should have been given its distance to us and quickly realized that we were seeing a very rare phenomenon called strong gravitational lensing," says Ariel Goobar, lead author of the study published today in Nature Astronomy and the director of the Oskar Klein Center at the University of Stockholm. "Such lensed objects can help us to uniquely probe the amount and distribution of matter at the inner core of galaxies."

Gravitational Lensing Explained

As predicted by Albert Einstein, light from one cosmic object that encounters a dense object on its way to us can undergo gravitational lensing. The dense object acts as a lens that can bend and focus the light. Depending on how dense the lens is and the distance between the lens and us, this warping effect can vary in strength. With strong lensing, the light from the cosmic object is so distorted that it is magnified and split into several copies of the same image.

Astronomers have been observing the gravitational bending of light since 1919, just a few years after Einstein developed the theory, but the transient nature of supernovae makes events such as SN Zwicky, also known as SN 2022qmx, very hard to spot. In fact, while scientists have spotted lensed duplicated images of distant objects called quasars many times before, only a handful of supernovae lensed into duplicated images have been found. Two of these cases were found at Palomar: SN Zwicky, and ciPTF16geu, discovered by the intermediate Palomar Transient Factory (iPTF), a predecessor to ZTF.

Discovering and Studying SN Zwicky

"SN Zwicky is the smallest resolved gravitational lens system found with optical telescopes. iPTF16geu was a wider system but had larger magnification," says Goobar.

Goobar and his international team employed a suite of astronomical facilities to follow up and study SN Zwicky after it was discovered by ZTF. The Near-IR Camera 2 (NIRC2) at the W. M. Keck Observatory on Maunakea in Hawaiʻi resolved SN Zwicky, revealing that the lensing of the supernova was strong enough to have created multiple images of the same object.

"I was observing that night and was absolutely stunned when I saw the lensed image of SN Zwicky," says Christoffer Fremling, a staff astronomer at the Caltech Optical Observatory who leads the ZTF supernova survey, called the Bright Transient Survey. "We catch and classify thousands of transients with the Bright Transient Survey, and that gives us a unique ability to find very rare phenomena such as SN Zwicky."

Supernovae, Dark Energy, and Cosmic Mysteries

SN Zwicky is classified as a Type Ia supernova. These are dying stars that end their lives with a light show that is always the same in brightness from event to event. This unique property was instrumental in revealing the universe's accelerated expansion in 1998 due to a yet unknown phenomenon called dark energy.

"Strongly lensed Type Ia supernovae allow us to see further back in time because they are magnified. Observing more of them will give us an unprecedented chance to explore the nature of dark energy," says Joel Johansson, a postdoctoral fellow at Stockholm University and a co-author on the study.

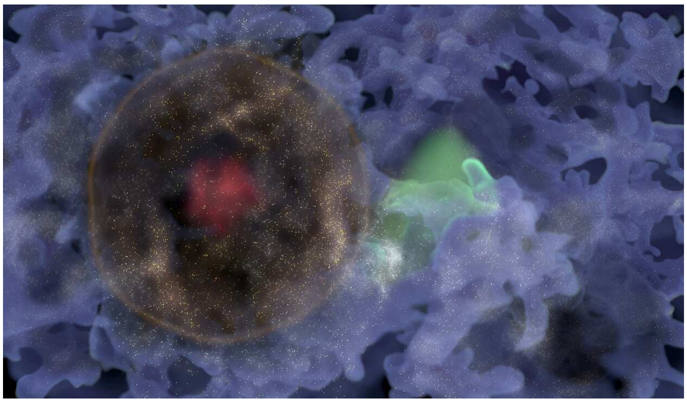
"What are missing components needed to model the expansion history of the universe? What is the dark matter that makes up the vast majority of the mass in galaxies? As we discover more 'SN Zwickys' with ZTF and the upcoming Vera Rubin Observatory, we will have another tool to chip away at the mysteries of the universe and find answers," says Goobar.

The ZTF Bright Transient Survey

To date, the ZTF Bright Transient Survey has discovered 7,811 confirmed supernovae. The main goal of the survey is to catalog and classify all extragalactic explosions that the instrument can reliably detect. Because ZTF rapidly scans wide swaths of the sky, it is currently the largest and most complete survey of its kind. Astronomers around the world use the Bright Transient Survey to find out what kinds of cosmic explosions exist, how common they are, and how bright they can get.

More Detail: https://scitechdaily.com/

Billion-light-year-wide 'bubble of galaxies' discovered



An artist's representation of the 'bubble of galaxies' Ho'oleilana, which spans a billion light years.

Astronomers have discovered the first "bubble of galaxies," an almost unimaginably huge cosmic structure thought to be a fossilized remnant from just after the Big Bang sitting in our galactic backyard.

The bubble spans a billion light years, making it 10,000 times wider than the Milky Way galaxy.

Yet this giant bubble, which cannot be seen by the naked eye, is a relatively close 820 million light years away from our home galaxy, in what astronomers call the nearby universe.

The bubble can be thought of as "a spherical shell with a heart," Daniel Pomarede, an astrophysicist at France's Atomic Energy Commission, told AFP.

Inside that heart is the Bootes supercluster of galaxies, which is surrounded by a vast void sometimes called "the Great Nothing".

The shell contains several other galaxy superclusters already known to science, including the massive structure known as the Sloan Great Wall.

Pomarede said the discovery of the bubble, which is described in research he co-authored that was published in The Astrophysical Journal this week, was "part of a very long scientific process".

It confirms a phenomenon first described in 1970 by US cosmologist - and future physics Nobel winner - Jim Peebles.

He theorized that in the primordial universe - then a stew of hot plasma - the churning of gravity and radiation created sound waves called baryon acoustic oscillations (BAOs).

As the sound waves rippled through the plasma, they created bubbles.

Around 380,000 years after the Big Bang the process stopped as the universe cooled down, freezing the shape of the bubbles.

The bubbles then grew larger as the universe expanded, similar to other fossilized remnants from the time after the Big Bang.

Astronomers previously detected signals of BAOs in 2005 when looking at data from nearby galaxies.

But the newly discovered bubble is the first known single baryon acoustic oscillation, according to the researchers.

'Unexpected'

The astronomers called their bubble Ho'oleilana - "sent murmurs of awakening" - taking the name from a Hawaiian creation chant.

The name came from the study's lead author Brent Tully, an astronomer at the University of Hawaii.

The bubble was discovered by chance, as part of Tully's work searching through new catalogs of galaxies.

"It was something unexpected," Pomarede said.

Tully said in a statement that the bubble is "so huge that it spills to the edges of the sector of the sky that we were analyzing".

The pair enlisted the help of Australian cosmologist and BAO expert Cullan Howlett, who "mathematically determined the spherical structure which best corresponded to the data provided," Pomarede said.

This allowed the trio to visualize the three-dimensional shape of Ho'oleilana - and the position of the archipelagos of galaxies inside it.

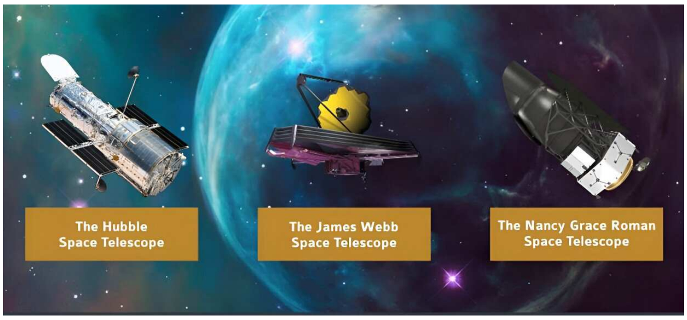
It may be the first, but more bubbles could soon be spotted across the universe.

Europe's Euclid space telescope, which launched into July, takes in a wide view of the universe, potentially enabling it to snare some more bubbles.

Massive radio telescopes called the Square Kilometre Array, being built in South Africa and Australia, could also offer a new image of galaxies from the viewpoint of the Southern Hemisphere, Pomarede said.

From: https://phys.org/news/2023-09-billion-light-year-wide-galaxies.html

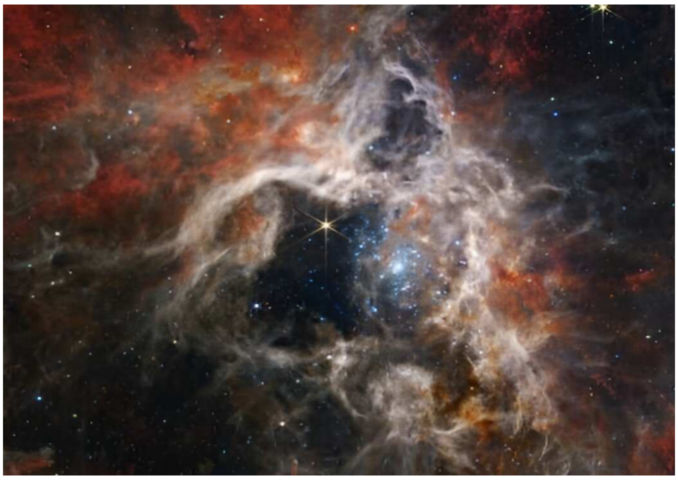
How Can We Bring Down The Costs Of Large Space Telescopes?



The JWST is barely a year into its mission and we're already anticipating the next space telescopes. NASA is already planning and developing the Nancy Grace Roman Space Telescope (formerly WFIRST) and the Habitable Worlds Observatory (formerly LUVOIR) for launch in 2027 and the late 2030s, respectively.

These space telescopes will likely be extremely expensive. However, a team of researchers thinks there are ways to bring the cost of space telescopes down. They've written a paper presenting their thoughts titled "Approaches to lowering the cost of large space telescopes." The lead author is Ewan Douglas, an Assistant Professor of Astronomy at the University of Arizona, Steward Observatory.

There's no doubting the scientific rationale for large space telescopes. They deliver results impossible to get in any other way. There's also no doubting their expense and their drain on NASA's budget. They can never be cheaper than ground-based telescopes, but ground-based telescopes simply can't perform the way space telescopes can.



Without space telescopes, we wouldn't have images like this. The JWST captured this image of the Tarantula Nebula in September 2022. Credit: NASA, ESA, CSA, STScI, Webb ERO Production Team

Nobody wants to give up the scientific progress stemming from powerful space telescopes. But it's hard to counter the criticisms that they're getting too expensive. Douglas and his co-authors have some ideas on how we can continue to generate new discoveries with space telescopes while making the cost more palatable.

Their paper focuses on a hypothetical 6.5 m mirror optical light that operates in space at room temperature. 6.5 meters is the same size as the JWST's mirror. They show how some technologies are becoming cheaper, how some technology that was cutting edge is now nearly off-the-shelf, and how spacecraft like SpaceX's Starship means we can launch telescopes with larger primary mirrors without building complex, expensive mirrors like the James Webb's.

Ground-based telescopes saw a pronounced drop in costs after 1980, and the researchers say the same thing can happen with space telescopes. "Thus, research and new economies of scale enabled by prior research into optics, commercial electronics, and the SpaceX StarShip could have a similar impact on space astronomy and drive the cost of multiple large observatories down.

Launching capabilities play a critical role in costs. Not just the expense of a rocket launch itself, but by restricting the size of a telescope's primary mirror. The JWST's primary mirror was folded to fit into the Ariane 5's payload fairing. That meant that it needed a complicated, expensive, and risky mirror that unfolded while it traveled to its position. Launch restrictions were a significant financial burden on the mission.

But SpaceX's Starship should be able to load a 6.5-meter mirror in one piece. "The fairing of the SpaceX Starship has the potential for a 6.5 m JWST-class telescope to be directly launched with a monolithic mirror, removing the cost and complexity of segmented mirror designs," they write. If that can be reliable, then the 6.5 mirror design could be used in multiple telescopes. Most of the cost of building a 6.5-meter mirror is in the primary optic material, and honeycomb borosilicate mirrors are relatively inexpensive. So instead of custom designing and building each mirror, we could reach a sort of economy of scale.

The authors say there is a standard 6.5-meter mirror that almost fits the bill, the "… field-proven Richard F. Caris Mirror Lab 6.5 m light-weighted borosilicate honeycomb mirror without modification." Honeycombs have the same advantages as other solid counterparts but are lighter and can be significantly larger. Borosilicate glass is used because it resists thermal expansion, is moldable at low temperatures, and is relatively inexpensive. For comparison, the JWST's mirror is made of beryllium and coated with a thin layer of gold.

A borosilicate mirror in a space telescope would require adaptive optics. But this is another area where ground-based telescopes have been a proving ground. The technology of adaptive optics and wavefront control is getting better and better and can be adapted to a 6.5-meter space telescope. Newer, faster CMOS sensors also help eliminate image distortion because they need less time to capture images, and they're also getting larger and cheaper.

Unlike the surface of the Earth, space is a radiation free-for-all. Electronics need to be able to work in this environment, and so does software. “Historically, purpose-built flight computers ran assembly language and required costly and niche software development skills,” the authors write. But that's changing. Commercial off-the-shelf (COTS) electronics are now being implemented in space missions, and so are common operating systems. For example, the Mars Ingenuity Helicopter runs on Linux, and so do some wavefront control systems on CubeSats.

The JWST sits at the sun-Earth L2 to do its business. It needs to be in a thermally stable environment for its powerful IR sensors to be effective. But it costs more to get the telescope there, and it requires more power to transmit its data. Douglas and his colleagues say there's another option, at least for optical telescopes, one used by TESS.

TESS is in a 13.7-day period in High Earth Orbit (HEO.) It used lunar gravity assist to get there, which helped lower launch costs. “The TESS HEO orbit provides a large continuous sky coverage in a thermally stable low radiation environment for relatively low Delta V, lowering the propulsion needs for space observatories and increasing potential data downlink relative to L2 orbits for the same transmitter power.” TESS's orbit should be stable for decades or longer without the need for propulsion.

Some advancements in telescope design lower the costs while not directly involving technology. Significant developments in design processes have streamlined procedures and reduced costs by saving time. “Over the past several decades, advances in development processes for software with version control, project management, test-based design, and continuous integration and deployment have increased the development pace of increasingly complex software,” the paper states.

Document management might not ignite much enthusiasm for most of us, but it's an example of a critical piece of the telescope design process that can benefit from improvement and lower costs. It takes thousands of people with specialized skills decades to design, build, and launch a space telescope. Streamlined communication methods can help lower costs. The authors mention examples like machine-readable documents, and using the open-source JSON file format and its schemas to reduce errors. Even change tracking and automated distribution of documents can be improved to help lower costs. “These tools make an iterative, prototype-heavy design process more feasible since lessons learned are captured naturally,” they explain.

Some of the changes outlined have already been used in SmallSats, CubeSats, and in some cases, even larger projects like the Nancy Grace Roman Space Telescope. In fact, SmallSats provide an encouraging look at how we can lower costs without sacrificing science.

From: https://phys.org/news/2023-09-large-space-telescopes.html

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Space Junk Includes:

- A glove lost by astronaut Ed White on the first American space-walk (EVA).
- A camera lost by Michael Collins near Gemini 10.
- Athermal blanket lost during STS-88.
- Garbage bags jettisoned by Soviet cosmonauts during Mir's 15-year life.
- A wrench, and a toothbrush.
- Sunita Williams of STS-116 lost a camera during an EVA.
- During an STS-120 EVA to reinforce a torn solar panel, a pair of pliers was lost,
- During anSTS-126 EVA, Heidemarie Stefanyshyn-Piper lost a briefcase-sized tool bag.

Matter Comprises of 31% of the Total Amount of Matter and Energy in the Universe

A research team relies on measuring the number of galaxy members to determine the mass of galaxy clusters

One of the most interesting and important questions in cosmology is, "How much matter exists in the universe?" An international team, including scientists at Chiba University, has now succeeded in measuring the total amount of matter for the second time. Reporting in The Astrophysical Journal, the team determined that matter makes up 31% of the total amount of matter and energy in the universe, with the remainder consisting of dark energy.

"Cosmologists believe that only about 20% of the total matter is made of regular or 'baryonic' matter, which includes stars, galaxies, atoms, and life," explains first author Dr. Mohamed Abdullah, a researcher at the National Research Institute of Astronomy and Geophysics-Egypt, Chiba University, Japan. "About 80% is made of dark matter, whose mysterious nature is not yet known but may consist of some as-yet-undiscovered subatomic particles."

"The team used a well-proven technique to determine the total amount of matter in the universe, which is to compare the observed number and mass of galaxy clusters per unit volume with predictions from numerical simulations," says co-author Gillian Wilson, Abdullah's former graduate advisor and Professor of Physics and Vice Chancellor for research, innovation, and economic development at UC Merced. "The number of clusters observed at the present time, the so-called 'cluster abundance,' is very sensitive to cosmological conditions and, in particular, the total amount of matter."

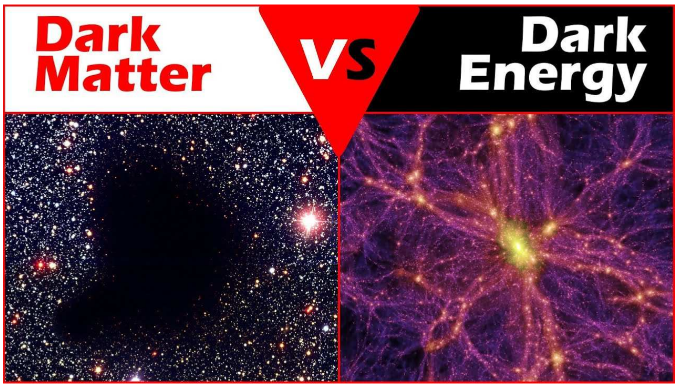
"A higher percentage of the total matter in the universe would result in more clusters being formed," says Anatoly Klypin from University of Virginia. "But it is difficult to measure the mass of any galaxy cluster accurately as most of the matter is dark, and we cannot see it directly with telescopes."

To overcome this difficulty, the team was forced to use an indirect tracer of cluster mass. They relied upon the fact that more massive clusters contain more galaxies than less massive clusters (mass richness relation: MRR). Because galaxies consist of luminous stars, the number of galaxies in each cluster can be utilized as a way of indirectly determining its total mass. By measuring the number of galaxies in each cluster in their sample from the Sloan Digital Sky Survey, the team was able to estimate the total mass of each of the clusters. They were then able to compare the observed number and mass of galaxy clusters per unit volume against predictions from numerical simulations. The best-fit match between observations and simulations was with a universe consisting of 31% of the total matter, a value that was in excellent agreement with that obtained using cosmic microwave background (CMB) observations from the Planck satellite. Notably, CMB is a completely independent technique.

"We have succeeded in making the first measurement of matter density using the MRR, which is in excellent agreement with that obtained by the Planck team using the CMB method," says Tomoaki Ishiyama from Chiba University. "This work further demonstrates that cluster abundance is a competitive technique for constraining cosmological parameters and complementary to non-cluster techniques such as CMB anisotropies, baryon acoustic oscillations, Type Ia supernovae, or gravitational lensing."

The team credits their achievement as being the first to successfully utilize spectroscopy, the technique that separates radiation into a spectrum of individual bands or colors, to precisely determine the distance to each cluster and the true member galaxies that are gravitationally bound to the cluster rather than background or foreground interlopers along the line of sight. Previous studies that attempted to use the MRR technique relied on much cruder and less accurate imaging techniques, such as using pictures of the sky taken at some wavelengths, to determine the distance to each cluster and the nearby galaxies that were true members.

From: https://www.sciencedaily.com/releases/2023/09/230913122704.htm



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LINKS, COMMENTS AND OBSERVATIONS

September Monthly Meeting (ZOOM Only)

Celestial Hide and Seek Eclipses, Transits and Occultations

Martin Lunn MBE

22nd September, 2023 19:30 PM

Zoom Login Details

https://us02web.zoom.us/j/83248711167?pwd=N2tGdmlmTXpBWEJZT2VTMlNkRkV0UT09

or

Meeting ID: 832 4871 1167
Passcode: cvlsqCT82_

About the talk: An eclipse of the Sun is one of the grandest sights in nature. The Moon passes in front of the Sun and daylight becomes darkness for a short period of time. We cannot be surprised that people living in the past were terrified by this spectacle. We will see how eclipses of the Sun and Moon occur, how they have affected history and how transits and occultations can help astronomers better understand the solar system.

About the speaker: Martin writes: **"**I studied for my degree in astrophysics whilst working as a guard on British Rail in the 1970s. From 1989 until 2011 I was Curator of Astronomy at the Yorkshire Museum in York, and in 1998 I was presented with an MBE for services to astronomy and education."

"I am a Fellow of the Royal Astronomical Society and have served a term on the council. I also present lectures on cruise ships all over the world, and to various clubs and societies at home. I have my own weekly Astronomy Show on a community radio station called Drystone Radio, which can be heard locally and on line. My show is probably the only weekly astronomy show on any radio station anywhere in the country. I also write a monthly 'What's in the night sky?' feature for the Craven Herald newspaper which covers the Yorkshire Dales."

Martin Lunn previously gave a talk in November 2021 about the early pioneers of Variable Star Astronomy, John Goodricke and Edward Pigott.

At The Observatory

1. **Please bring a torch.**
2. **Make sure you close and lock the car park gate if you are the last to leave.**

Articles Needed

NZ needs relevant content.
Contact details on page 1.

Strange Facts

Venus has a slow axis rotation which takes 243 Earth days to complete its day. The orbit of Venus around the Sun is 225 Earth days, making a year on Venus 18 days less than a day on Venus.

The Andromeda Galaxy is approaching the Milky Way at about 110 kilometres per second and in about 3.75 billion years the two will collide to form a giant elliptical galaxy.

The atmosphere on Earth is proportionately thinner than the skin on an apple.

Every year, the Moon is moving away from Earth by 3.8 centimeters.

Space is so dark because we can see light only when it hits an object and bounces off it

Stars don't twinkle until their light passes through Earth's atmosphere.

Every year, the Sun evaporates 100,000 cubic miles of water from Earth. That weighs 400 trillion tonnes!