`"The Southern Cross"

HERMANUS ASTRONOMY CENTRE NEWSLETTER

JUNE 2021

Monthly meeting This months **Zoom meeting** will take place on the evening of **Monday 21 June,** starting at **19.00.** Access details will be circulated to members closer to the time. The presenter is **Dr Rob Adam**, Director of the South African Square Kilometre Array (SKA) Radio Telescope project. The title of his talk is `**Introducing the SKA Observatory'.** See below for further details.

2021 meeting dates For your diaries. The remaining dates of the monthly meetings for 2021 are as follows: 21 June, 19 July, 16 August, 20 September, 18 October and 15 November.

WHAT'S UP?

Meteor showers: θ Ophiucids, June Lyrids Meteor showers occur when Earth passes through the path of a stream of meteoroids which has been left as the remnant of the disintegration of an object, usually a comet, as it passes the Sun. The cosmic debris enters Earth's atmosphere at very high speeds. The resulting friction causes the small dust particles or meteoroids to burn up, leaving a trail of excited ionised particles in their paths, the result of which forms the visible light or 'shooting stars' which can be observed. The debris forming showers is usually tiny, smaller than a grain of sand, and burns up in the upper atmosphere. Originating from one point in the sky, the showers are named for the constellations located in the area of sky from which they radiate. Several showers occur at the same time each year, their location in the same place (usually identified by the closest named star or constellation). June is the most favourable month to look for meteor shower, this year. The θ Ophiucids shower can be found to the right of Antares (Scorpius) all night from 20.00 from 8 – 16 June, peaking on the 13th. The constellation Lyra (the Lyre) has two annual showers. The June one can be seen lowish towards the North-east from 23.30 – 02.00 from 11 – 21 June, peaking on the 16th. The meteors radiate from near the constellations brightest star Vega (alpha Lyrae). Both these showers tend to be weak, but the dark skies associated with their appearance, this year, may enable them to be observed.

LAST MONTH'S ACTIVITIES

Monthly centre meeting At the Zoom meeting on 17 May, amateur astronomer Clyde Foster, who recently discovered 'Clyde's Spot' on Jupiter, gave a fascinating and absorbing presentation on "The planets up close and personal: my journey into planetary imaging'. Clyde explained how retirement enabled him to indulge in his long-held interest in

stargazing. Light pollution challenges at his Centurion home led to him focussing on large objects – Mars, Jupiter and Saturn. He became part of the small, but dedicated group of amateur planet observers, filling in a gap in observation in this part of the southern hemisphere. He also realised the contribution such observers can make to the images obtained by professional astronomers. Over time, the value of his images resulted in him becoming part of the global observing community. It was notable in the way Clyde described this relationship that he still feels humbled by the fact that leading astronomers recognise and value his contributions, to the extent of inviting him to present conference papers and, sometimes, being included in the author list of peer-reviewed articles.

The famous discovery of 'Clyde's Spot' a storm on Jupiter was the result of the ongoing amateur/professional relationship involved in the Juno mission. Amateur astronomers identify possible objects of interest, which the professionals then programme the spacecraft to image. In May 2020, Clyde observed and imaged a new feature, informed the Juno controllers, and Juno also took images. NASA confirmed the new cyclonic storm, named it 'Clyde's Spot' and released the finding to the international press. The spot was potentially a temporary feature, but Clyde explained that its behaviour suggests it may become longlasting. Clyde will continue to monitor it in addition to the observational work he is continuing to do on other solar system planets.

Interest groups

Cosmology At the Zoom meeting, held on 3 May, Derek Duckitt presented the first part of a 2-part series of presentations on Quantum loop gravity by Carlo Ravelli.

Astro-photography The meeting scheduled for 10 May was cancelled.

Other activities

Educational outreach No activities took place during May.

THIS MONTH'S ACTIVITIES

Monthly centre meeting This month's **Zoom meeting**, will take place on the evening of **Monday 21 June,** starting at **19.00**. Access details will be circulated to members. The presenter is **Dr Rob Adam,** Director of the South African Square Kilometre Array (SKA) Radio Telescope project. The title of his presentation is '**Introducing the SKA Observatory'.**

Synopsis (taken largely from the SKA website): "The Square Kilometre Array (SKA) project is an international effort to build the world's largest radio telescope, with eventually over a square kilometre (one million square metres) of collecting area. Few projects come close to the scope and ambition of the Square Kilometre Array (SKA) as a scientific endeavour.

The scientific question to be investigated include (1) How do galaxies evolve? (2) What is dark energy? (3) Was Einstein right about gravity? (4) What generates giant magnetic fields in space? (5) How were the first black holes and stars formed? (6) Are we alone in the universe?

Alongside the talents of thousands of skilled professionals and the development of groundbreaking technology, the SKA requires a governance structure capable of delivering this huge global project. Geographically distributed between three host countries Australia, South Africa and the United Kingdom, and with more than a dozen member nations, the SKA demands an extraordinary level of international cooperation. As it becomes a reality on the ground, facilitating the smooth movement of equipment, money and people across borders is essential. To this end the SKA Observatory (SKAO) has been established as an intergovernmental organisation through international treaty, similar to CERN and the European Space Agency. The Observatory is the legal entity responsible for constructing

and operating the SKA telescopes in Australia and South Africa, with its headquarters in the United Kingdom."

Biography Rob Adam was appointed Director of the South African Square Kilometre Array (SKA) Radio Telescope project in 2016 and became Managing Director of the SA Radio Astronomy Observatory (SARAO) when this new National Facility was declared by the Minister of Science and Technology in 2017.

Rob matriculated from Bishops in Cape Town in 1972 and graduated from the University of Cape Town with a first class Honours in Chemistry in 1978. In 1982 he was sentenced to 10 years imprisonment for activities undertaken on behalf of the then banned African National Congress. While in prison he studied obtained Honours and Masters degrees in Theoretical Physics and submitted his PhD thesis in 1990 after his release, following the unbanning of the ANC and other movements.

From an academic perspective, Rob has held teaching and research positions in the United Kingdom, the Netherlands and South Africa. He has co-authored over 40 refereed articles in theoretical physics, chemistry and astronomy, published widely on science and technology policy and co-authored a book on science and technology in the Republic of Chile. He has also been a Professor of Physics at both the University of Pretoria and the University of South Africa and has served on the Council of the Academy of Sciences of South Africa.

In 1995, after the first democratically elected South African administration assumed office, Rob joined government. In 1999 he was appointed Director-General of the Department of Science and Technology and held this position until 2006, when he was appointed Chief Executive Officer of the South African Nuclear Energy Corporation (Necsa), South Africa's statutory nuclear technology company. In 2012 Rob joined the private sector and became Group Executive: Nuclear at Aveng, a publicly listed multinational infrastructure company, from where he moved to his current positions at SARAO and the SKA. He is a member of the Board of the SKA (representing South Africa) and has chaired or served on numerous other Boards and Councils.

Interest group meetings

The **Cosmology** group meets on the first Monday of each month. The next meeting, on the evening of **Monday 7 June** will be shown **via Zoom**. Access and start time details will be circulated to members. The topic is part 2 of the presentations on Quantum loop gravity by Carlo Ravelli.

For further information on these meetings, or any of the group's activities, please contact Derek Duckitt at derek.duckitt@gmail.com

Astro-photography This group normally meets on the second Monday of each month. Members are currently communicating digitally about image processing they do at home. The next meeting will take place **via Zoom** on **Monday 14 June**.

To find out more about the group's activities and the venue for particular meetings, please contact Deon Krige at astronomy.hermanus@gmail.com

For further information, please contact Deon Krige at deonk@telkomsa.net

Other activities

Stargazing While no events will take place during the coronavirus pandemic, members are encouraged to submit their own images for circulation to the membership. Please e-mail them to petermh@hermanus.co.za

FUTURE TRIPS

No outings are being planned, at present.

2021 MONTHLY MEETINGS

Unless stated otherwise, meetings take place on the **third Monday** of each month. For the present, they will be presented via Zoom. The remaining dates for this year are as follows: 21 June, 19 July, 16 August, 20 September, 18 October and 15 November.

Remaining external speakers for 2021 include Rob Adam (June), Lee-Anne McKinnell (July), Case Rijsdijk (September) and Pieter Kotzé (October). The other presenters are Centre members, Johan Retief and Jenny Morris. Details will be circulated closer to the time, each month.

ASTRONOMY GEARING'S POINT ASTRONOMY EDUCATION CENTRE (GPAED)

Municipal agreement has been obtained for this project, which is to be located within the existing whale-watching area at Gearing's Point.. Work is underway to obtain the necessary quotes and other budgetary requirements in order to submit an amended proposal to the National Lottery Commission.

The **Friends of the Observatory campaign** was launched several years ago when preliminary work began on plans to construct an astronomical observatory in Hermanus. Over the years, members have been very generous, for which we are deeply grateful. It may seem logical to assume that, now money has been awarded by the National Lotteries Board, pledge monies are no longer needed. Unfortunately, that is not the case. NLC funds can only be used once the plans have been formally approved by the Municipality.

We would, therefore, be very grateful if members could either continue to contribute to the campaign or start becoming a contributor. Both single donations and small, regular monthly donations, of any amount, are welcome. Contributions can take the form of cash (paid at meetings), or online transfer, The Standard Bank details are as follows:

Account name – Hermanus Astronomy Centre
Account number – 185 562 531
Branch code – 051001

If you make an online donation, please include the word 'pledge', and your name, unless you wish to remain anonymous.

ASTRONOMY NEWS\\

Chandra spots evidence for long-standing theory of how stars explode 3 May: Cassiopeia A, named for its location in the famous w-shaped constellation, is one of the Milky Way's youngest supernova remnants. Only about 350 years old, this stunning sphere of dust and gas is all that's left of a massive star that ended its life in a powerful explosion. Although supernova remnants are not rare, there is still much that astronomers do not know about exactly how massive stars explode and die. A new discovery made with NASA's Chandra X-ray Telescope is shedding light on the situation.

This composite image shows different elements spread throughout the Cassiopeia A supernova remnant: titanium (blue), the ratio of silicon to magnesium (green), iron (orange), and oxygen (purple). Data are overlaid on an optical light image (yellow) captured by Hubble. Chandra: NASA/CXC/RIKEN/T. Sato et al; NuSTAR: NASA/NuSTAR; Hubble: NASA/ STScI

Here is what astronomers believe happens when a massive star explodes: First, the star's core begins to collapse under its own gravity. That collapse generates shock waves, which rebound inside the core and begin to move outward through the star, ripping it apart in a

spectacular supernova. Along the way, those shock waves transform some of the star's material into other elements. Researchers believe supernovae are the source of numerous heavy elements - such as those further down than iron on the periodic table - found on Earth today. That includes titanium, which astronomers have spotted (coloured blue in the image above) in Cassiopeia A before. However, Chandra recently spotted a different type, or isotope, of titanium than previously detected. Different isotopes of a given element have the same number of protons but different numbers of neutrons, which affects whether or not they will decay into lighter elements over time.

This newly spotted isotope is stable, meaning it does not decay. Stable titanium has never before been seen in any supernova at all. That is important because it could solve a long-standing mystery about how supernovae occur at all. In computer simulations, those initial shock waves created when the core collapses lose momentum quickly, dissipating before the supernova explosion can even occur. However, since supernovae obviously take place, something is missing. Adding in the effects of neutrinos - lightweight particles created in the star's collapse - solves the problem by prompting the creation of bubbles of material that quickly expand, lending the shock wave the energy it needs to keep going. So far, astronomers had been unable to find evidence to support the theory that neutrinos can drive such bubbles to power shock waves, specifically. This new detection changes that: The stable titanium isotope that Chandra spotted in Cassiopeia A - alongside other elements such as chromium and iron (coloured orange) - matches the elements expected to form inside the bubbles created by a neutrino-driven explosion. Specifically, the temperature and density of material in such bubbles create the conditions needed to form the types of elements seen in the remnant. That is pretty significant evidence that the neutrino theory is correct, at least for explosions like Cassiopeia A. By: Alison Klesman

Massive flare on Proxima Centauri could spell bad news for any alien life 5 May: The Sun is not the only star to produce stellar flares. On 21 April 2021 a team of astronomers published new research describing the brightest flare ever measured from Proxima Centauri in ultraviolet light. To learn about this extraordinary event – and what it may mean for any life on the planets orbiting Earth's closest neighbouring star – The Conversation spoke with Parke Loyd, an astrophysicist at Arizona State University and co-author of the paper. Excerpts from our conversation are below and have been edited for length and clarity.


Proxima Centauri is the closest star to the solar system and is home to a potentially habitable planet. Hubble/European Space Agency/WikimediaCommons, CC BY-SA

Q. Why were you looking at Proxima Centauri? A. Proxima Centauri is the closest star to this solar system. A couple of years ago, a team discovered that there is a planet – called Proxima b – orbiting the star. It's just a little bit bigger than Earth, it's probably rocky and it is in what is called the habitable zone, or the Goldilocks zone. This means that Proxima b is about the right distance from the star so that it could have liquid water on its surface. But this star system differs from the Sun in a pretty key way. Proxima Centauri is a small star called a red dwarf – it's around 15% of the radius of our Sun, and it's substantially cooler. So Proxima b, in order for it to be in that Goldilocks zone, actually is a lot closer to Proxima Centauri than Earth is to the Sun. You might think that a smaller star would be a tamer star, but that's actually not the case at all – red dwarfs produce stellar

flares a lot more frequently than the Sun does. So Proxima b, the closest planet in another solar system with a chance for having life, is subject to space weather that is a lot more violent than the space weather in Earth's solar system.

Q. What did you find? A. In 2018, my colleague Meredith MacGregor discovered flashes of light coming from Proxima Centauri that looked very different from solar flares. She was using a telescope that detects light at millimetre wavelengths to monitor Proxima Centauri and saw a big of flash of light in this wavelength. Astronomers had never seen a stellar flare in millimetre wavelengths of light. My colleagues and I wanted to learn more about these unusual brightenings in the millimetre light coming from the star and see whether they were actually flares or some other phenomenon. We used nine telescopes on Earth, as well as a satellite observatory, to get the longest set of observations – about two days' worth – of Proxima Centauri with the most wavelength coverage that had ever been obtained. Immediately, we discovered a really strong flare. The ultraviolet light of the star increased by over 10,000 times in just a fraction of a second. If humans could see ultraviolet light, it would be like being blinded by the flash of a camera. Proxima Centauri got bright really fast. This increase lasted for only a couple of seconds, and then there was a gradual decline. This discovery confirmed that indeed, these weird millimetre emissions are flares.

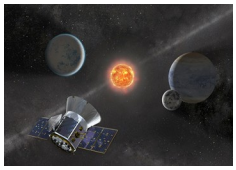

Proxima b – shown here in an artist's rendering. ESO/ M. Kornmesser, CC BY

Q. What does that mean for chances of life on the planet? A. Astronomers are actively exploring this question at the moment because it can kind of go in either direction. When you hear ultraviolet radiation, you're probably thinking about the fact that people wear sunscreen to try to protect ourselves from ultraviolet radiation here on Earth. Ultraviolet radiation can damage protein and DNA in human cells, and this results in sunburns and can cause cancer. That would potentially be true for life on another planet as well. On the flip side, messing with the chemistry of biological molecules can have its advantages – it could help spark life on another planet. Even though it might be a more challenging environment for life to sustain itself, it might be a better environment for life to be generated to begin with.

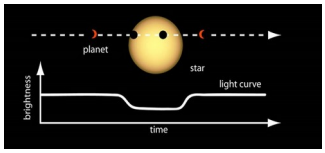
But the thing that astronomers and astrobiologists are most concerned about is that every time one of these huge flares occurs, it basically erodes away a bit of them atmosphere of any planets orbiting that star – including this potentially Earth-like planet. And if you don't have an atmosphere left on your planet, then you definitely have a pretty hostile environment to life – there would be huge amounts of radiation, massive temperature fluctuations and little or no air to breathe. It's not that life would be impossible, but having the surface of a planet basically directly exposed to space would be an environment totally different than anything on Earth.

Q. Is there any atmosphere left on Proxima b? A. That's anybody's guess at the moment. The fact that these flares are happening doesn't bode well for that atmosphere being intact – especially if they're associated with explosions of plasma, like what happens on the Sun. But that's why we're doing this work. We hope the folks who build models of planetary atmospheres can take what our team has learned about these flares and try to figure out the odds for an atmosphere being sustained on this planet. By: R O Parke Loyd

How TESS hunts more than just exoplanets 14 May: NASA's Transiting Exoplanet Survey Satellite, TESS, has identified more than 2,000 potential exoplanets in our local region of the Milky Way. Launched in 2018, TESS has already surveyed almost the entire sky once, and it is now on its second pass. Along the way, TESS has also serendipitously found several objects that are not planets, highlighting its value as a multidisciplinary mission.


Artist's concept of TESS, designed to find planets around other stars. NASA

Among those unexpected finds is a recent gamma-0ray burst (GRB), which TESS spotted in October 2020. GRBs are short-lived but powerful explosions that astronomers believe occur either when a massive star explosively dies or when two neutron stars merge. In both cases, the result is a black hole. These events release as much energy in a few seconds or minutes as the Sun puts out over its entire lifetime. Another NASA telescope, Swift-BAT, discovered this GRB first. However, Swift-BAT was unable to follow up on the blast immediately after its detection because it occurred too close to the Moon. Fortunately, TESS happened to be staring at just the right part of the sky - unhindered by the Moon from its viewpoint - and caught the event by sheer luck. TESS recorded the burst, which grew as bright as magnitude 15.1 for several minutes before it faded away. That brief window of observation was crucial, providing astronomers with the data needed to calculate the GRB's distance - nearly 12 billion light-years - among other things. "Our findings prove this TESS telescope is useful not just for finding new planets, but also for high-energy astrophysics," said Krista Lynne Smith of Southern Methodist University in Dallas, Texas. Smith led the work on the GRB,



The transit method detects planets by staring at stars to watch for dips in brightness that occur when a planet crosses in front of the disk. NASA Ames

TESS hunts for planets by staring at nearby stars in a single patch of the sky for roughly 28 days straight. It then repeats the process for another patch of sky. Over the course of two years, the satellite steps through the entire Northern and Southern Hemispheres. While focused on a single sector, TESS takes frequent images, hoping to catch planetary transits. These occur when an exoplanet passes in front of its host star from our point of view, slightly dimming the star's brightness. Utilising this technique means TESS excels at detecting other transient events, too, such as supernovae, stellar flares, asteroids, and comets. It is also perfect for spotting binary star systems, which can transit just like planets. As TESS observations are sent back to Earth, they pass through a computerized pipeline that identifies objects and events of interest, which researchers can then quickly follow up on.

Even before the mission started science operations, while still testing its systems, TESS captured images of Comet C/2018 N1 (NEOWISE) streaking through the constellation Piscis Austrinus. In its first month of official observations, which covered the first of 26 total sectors of the sky, TESS spotted dozens of transient events, including six supernovae (all in other galaxies). That is as many supernovae as the now-defunct Kepler space

telescope - which also looked for planetary transits but did so in only a single small region of the sky - found in four years. Although these finds do not add to the known catalogue of exoplanets, they still provide astronomers with vital data about our universe.

By: Alison Klesman

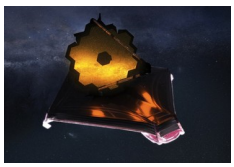
James Webb Space Telescope launch delay "likely", says government report 14 May: NASA officials have acknowledged that the scheduled October launch of the James Webb Space Telescope (JWST) could be pushed back yet again, according to a report from the Government Accountability Office (GAO) released on 13 May. This time, the issue is not with the telescope. Instead, it is with the usually reliable, European-produced Ariane 5 rocket, which is slated to carry JWST aloft on 31 October from Kourou, French Guiana. "According to NASA project officials, the JWST launch date will likely be delayed beyond October 2021 due to anomalies discovered in the JWST launch vehicle," says the report.


An Ariane 5 rocket lifts off from French Guiana on 25 September 2018, carrying two telecom satellites into space. ESA/CNES/Arianespace

The issue lies with the Ariane 5's fairing, the nose cone that protects its payload as it accelerates up through the atmosphere. Once the vehicle reaches space, the fairing separates from the rocket in two pieces and falls away. In two recent launches, the rocket experienced "unexpected vehicle accelerations" during fairing separation, according to the GAO report. As a result, Ariane 5 launches have been postponed while the European Space Agency and Arianespace, the rocket's manufacturer, investigate the issue.

The good news is that any potential delay may only be a matter of weeks, rather than months or years. The JWST launch will not go ahead until an Ariane 5 has flown and successfully demonstrated a fix to the issue, says the report. There are two Ariane 5 launches - planned for June and August of 2021 - ahead of JWST's scheduled October flight. Although NASA has not officially announced any revision to JWST's current October 31 launch date, recent public comments reported by Space News indicate officials expect it will take roughly four months to prepare JWST after Ariane 5 is again approved for flight. So, if the June launch shows the fairing issue is resolved, JWST could be set to fly in November.

A delay of a few weeks - or even a few months - would be far from the worst delay James Webb has faced so far. As the long-awaited successor to the Hubble Space Telescope, JWST is already seven years behind its initial launch target of June 2014. Furthermore, its budget has nearly doubled, from $5 billion to an estimated $9.7 billion. In July 2020, when NASA pushed back JWST's launch from March 2021 to October 2021, it cited the COVID-19 pandemic, "as well as technical challenges". Encouragingly, the GAO report found that work on JWST is still steadily moving forward, and "has made significant technical progress" since the most recent launch delay. For instance, earlier this week, the telescope passed a milestone as workers commanded it to unfurl its golden, 6.5-metre primary mirror — the last time it will do so on Earth. The test was the final preflight check of the intricate deployment process it will undergo when it reaches space.


The James Webb Space Telescope's mirror and science instruments are protected from the Sun by a sunshade. Adriana Manrique Gutierrez, NASA Animatore

"The completion of this last test on its mirrors is especially exciting because of how close we are to launch later this year," said Ritva Keski-Kuha, JWST's deputy optical telescope element manager. Considering the latest issues with the Ariane 5, though, it seems the JWST team may have to wait a little bit longer than they would like. By: Mark Zastrow

Have astrophysicists finally discovered primordial black holes? 19 May: Black holes come in a number of varieties, depending on how they are formed. Conventional black holes form when stars run out of fuel and collapse in on themselves. If the star is massive enough, about three to ten times the mass of our Sun, it forms a black hole. Another type are the supermassive black holes which sit at the centre of many galaxies and are many millions of times more massive than our Sun. There is plenty of evidence of both these types of black holes. Then there are primordial black holes, much more mysterious objects that are thought to have formed soon after the Big Bang. The thinking is that random fluctuations in the distribution of mass in the early universe must have created some regions dense enough to form black holes. However, nobody knows if primordial black holes actually exist. Astronomers have not been able to gather the evidence.

That is beginning to change. In 2016, astronomers began operating a gravitational wave detector called LIGO that can measure the way the universe rumbles when two distant black holes collide. Since then, they have spotted 47 collisions between black holes of all kinds of different masses. That has given them an interesting database to study. Now, the latest analysis suggests that more than a quarter of these collision involved primordial black holes. "If confirmed, these results would imply that the LIGO/Virgo collaboration could have already detected up to 24 binary black holes formed in the early universe," say Gabriele Franciolini at the University of Geneva and colleagues, who carried out the data analysis. This would be the first observation of any primordial black hole.

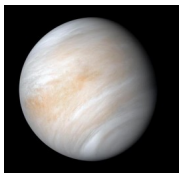
First some background. The new database of black hole collisions has thrown up a number of conundrums. Chief among these is that some of the observed black holes are too big to have formed via the gravitational collapse of stars. These black holes must have formed in a different way. That is where primordial black holes come in. The main difference between them and those formed from stars is the range of masses they can take. In theory, these black holes can be tiny - just 10^-8 kilogram - or they can be huge at many times the mass of our Sun. However, various models of the universe rule out the existence of primordial black holes of certain sizes. For example, the British cosmologist Stephen Hawking predicted that black holes would emit radiation and over time, this would cause them to shrink. If so, any black hole born soon after the Big Bang with a mass less than about 10^11 kg will have evaporated by now. Astronomers have also looked for tell-tale signs that larger primordial black holes would produce. For example, their gravitational fields should act like powerful lenses, magnifying distant objects as they pass in front of them.

However, astronomers have not observed these kinds of 'microlensing' events. That does not rule out the existence of primordial black holes but it does place important limits on

how many there can be. Another important factor is how many black holes of stellar origin there should be. This depends on how often they must have formed throughout the history of the universe. Once again there are numerous theories for how this might have happened in star clusters, in gas clouds and so on. For astronomers studying the dataset of black hole collisions, the goal is to take into account all these competing factors to see which theories and constraints are consistent with the data and which are not. That turns out to be a difficult task but the latest study has managed it.

This study uses a powerful statistical technique called Bayesian analysis. It takes into account a wide range of theories for how black holes of stellar origin would have added to a population of primordial black holes from the early universe. In this way, it can show that black holes are so common that stellar formation cannot account for all of them. So there must be a significant population of primordial black holes as well. "The evidence for a primordial population is decisively favored compared to the null hypothesis," say the team. That is an interesting result, not least because primordial black holes may be able to help another important mystery. This is that the universe seems to be filled with dark matter that we cannot see but nevertheless has a gravitational pull on the stuff we can see. Nobody knows what dark matter is made of, but one theory is that primordial black holes could account for this mass. The new evidence that primordial black holes do exist will help astrophysicists hunting for dark matter candidates to sharpen their searches. However, the case for primordial black holes is not yet complete. "Our results suggest the tantalizing possibility that LIGO/Virgo may have already detected black holes formed after inflation," say the team. Tantalisng it may be, but not yet certain. Astrophysicists will need more data to be certain and for that they will have to wait for the next generation of gravitational wave detectors that are currently being designed. By:The Physics arXiv Blog

What echoing radio waves taught us about Venus 26 May: Venus is often called Earth's sibling planet. Yet despite similarities in size and composition, this nearby world is hellish, unlike Earth's paradisical climes. Shrouded in clouds of sulphuric acid that hide a surface with temperatures that can reach 471 degrees Celsius, even six decades of successful robotic exploration have left many Venusian enigmas unanswered. Now that hass changed. Jean-Luc Margot of the University of California, Los Angeles, and his team have used a clever way of analysing radio waves to pin down several of Venus's most basic properties. It took them only 15 years.


Venus is swathed in a thick atmosphere that makes studying its surface challenging. NASA/JPL-Caltech

Using the revolutionary technique, Margot's team measured Venus' axial tilt (the difference between the planet's rotational axis and a line perpendicular to its orbital plane), day length, moment of inertia (a factor that affects how the planet spins, based on how its interior is structured), and core size. Previous estimates of these properties have significant uncertainties or varied from one measurement to the next. Such uncertainties have real-world consequences: For example, current ambiguities mean the position of a given location on Venus could be off by up to 30 kilometres after three decades. That is not the kind of error one wants when trying to put a lander on the surface.

Margot's journey began in 2001, when he received a memo from a colleague about a radio telescope technique first discussed in the early 1960s. After concluding the idea was sound, he says, "it was worth figuring out the practical implementation." Margot calls the technique radar speckle tracking. Imagine a rotating disco ball with a spotlight shining on it. Any reflected light appears speckled, with each surface on the ball bouncing back light at a slightly different angle. Now imagine that Venus, with its rotating, irregular surface, is the disco ball. A radio telescope dish on Earth is the spotlight, sending out a powerful blast of radio waves. And the echo that bounces back appears speckled because Venus' surface is not perfectly smooth.


This computer-generated global view of Venus' surface comes from data taken by the Magellan spacecraft. Because the planet's surface is not completely smooth, each region reflects light differently. NASA/JPL-Caltech

To get the most accurate measurements, the team needed to receive echoes at two widely spaced locations. The difference in time between when one antenna sees the echo and the other is related to how fast Venus is spinning. And the amount by which the signals appear identical or different between the two locations is related to Venus' tilt. Both receivers must record the echo for the observation to work. Margot's team used NASA's 70-meter radio antenna at its Goldstone Deep Space Communications Complex in California and the 100-meter Green Bank radio telescope in West Virginia, more than 3,000 km away. They first used the technique on Mercury - a planned research project that had already been approved for funding. It worked beautifully, says Margot. They measured the planet's rotation period with an accuracy of 0.001 percent. The team also determined that the planet's outer core is molten, which had not previously been known.

Getting the most accurate measurements required observing for a long period of time. The Mercury observations took about 10 years. Why did Venus take 15? Two major reasons were Venus's tiny axial tilt and the planet's precession (the motion of Venus' spin axis over time, the same way a spinning top will wobble). "The precessional motion for Earth and Venus is actually about the same," Margot says. "What is different is that Earth has a substantial [axial] tilt" - 23.4° - "so [its pole] traces this large cone on the sky." By comparison, Venus's axial tilt is around 2.7°. "That means a tiny little cone in the sky and a motion of the pole of only 2" per year." That requires many years of observation to measure a significant change. On top of all that, observation time with the Goldstone antenna was very limited. The dish is part of the Deep Space Network used to communicate with various space probes. Often, the team's scheduled time with the dish would be cancelled in lieu of a higher-priority request for the facility.

The team began observing Venus in 2006. Originally, they asked for 121 separate observing sessions and ultimately got about 50. By 2020, they had managed to make 21 observations that produced usable data. "It's a challenging measurement to make and it requires both high precision and patience," Margot reaffirms. The results of their patience and precision are remarkable. The team found that the average day on Venus (between 2006 and 2020) was 243.0226 Earth days long. What's more, the Venusian day varies in length by as much as 20 minutes. Margot thinks this is caused in part by Venus's extremely dense atmosphere, which, unlike the solid surface below, has a rotation period

of just four days. As the atmosphere "sloshes about" above Venus, it transfers some angular momentum to the planet itself. The team also found that Venus's axis is tilted by 2.6392°, a tenfold increase in accuracy over earlier estimates. The precession rate - how fast Venus' pole wobbles - is 44.58" per year, which means the pole draws a complete circle on the sky every 29,000 years. A more accurate precession rate gave the team a measure of the planet's moment of inertia, which in turn gave a rough estimate of the size of Venus' core, which was previously unknown. Margot's team found it is roughly 3,500 km across - about the same size as Earth's.

Do the similarities stop there? Our planet's core has an outer molten layer and a solid centre, but what about Venus' core? At this point, Margot says, we cannot be certain. Recent computer modelling suggests it could be either solid or molten, or perhaps solid at the centre with a molten outer region, like Earth's. Margot thinks it's probably entirely liquid, but would love for additional data from ongoing speckle observations to confirm it. Alternatively, he says, direct observational evidence for the core's size could come from tracking the motion of an orbiter around Venus and measuring tidal deformations induced in the planet by the Sun. "The ultimate best way [to learn about the core] is to have seismometers on the surface; but that's not going to happen soon," he adds, because of the planet's hellish conditions.

While they continue their work on Venus, Margot's team is also using radar speckle tracking on Jupiter's moons Europa and Ganymede. Astronomers strongly believe Europa has a global ocean beneath its icy surface and Ganymede likely may as well. However, using this technique to observe these moons is far more challenging than Mercury or Venus because of the distance involved, so the radar echoes received over that vast distance are thousands of times weaker. The team's early results, though, already suggest Europa "has an exterior layer that is decoupled from the interior of the body," Margot says, confirming that it does indeed have a subsurface global ocean. By: Joel Davis

First evidence of cell membrane molecules in space 28 May: The origin of life is one the great unanswered questions in science. One piece of this puzzle is that life started on Earth 4.5 billion years ago, just a few hundred million years after the formation of the Solar System, and involved numerous critical molecular components. How did all these components come to be available so quickly? One potential explanation is that the Earth was seeded from space with the building blocks for life. The idea is that space is filled with clouds of gas and dust that contain all the organic molecules necessary for life. Indeed, astronomers have observed these buildings blocks in interstellar gas clouds. They can see amino acids, the precursors of proteins and the machinery of life. They can also see the precursors of ribonucleotides, molecules that can store information in the form of DNA. However, there is another crucial component for life – molecules that can form membranes capable of encapsulating and protecting the molecules of life in compartments called protocells. On Earth, the membranes of all cells are made of molecules called phospholipids, but these have never been observed in space. Until now.

Víctor Rivilla at the Spanish Astrobiology Centre in Madrid and colleagues, have made the first detection in space of ethanolamine, a crucial component of the simplest phospholipid. The discovery suggests that the interstellar medium is brimming will all the precursors for life. "This has important implications not only for theories of the origin of life on Earth, but also on other habitable planets and satellites anywhere in the Universe," says the team. The group made their discovery by analysing light from an interstellar cloud of gas and

dust called Sagittarius B2, just 390 light years from the centre of the Milky Way. Astronomers have long known of this region as a rich reservoir of organic molecules, ices and dust particles. Ethanolamine has the chemical formula NH2CH2CH2OH. The team simulated the spectrum that this molecule ought to produce at the cold temperatures thought to exist in the cloud. They then looked for, and found, clear evidence of this spectrum in light that had passed through the cloud.

Although never before spotted in space, astronomers have found ethanolamine in meteorites. How it got there has been an issue of some debate with some researchers arguing it could only have formed through an unusual set of reactions on a parent asteroid. The new discovery suggests ethanolamine is much more widespread. On Earth, it forms the hydrophilic head of phospholipid molecules that self-assemble into cell membranes. Rivilla and colleagues say its discovery in interstellar clouds suggests "ethanolamine could have been transferred from the proto-Solar nebula to planetesimals and minor bodies of the Solar System, and thereafter to our planet." That could have led to the formation of cells in the prebiotic soup from which our earliest ancestors emerged. A more radical idea is that ethanolamine might allow the formation of protocells in the interstellar medium itself. This is rich in other prebiotic components such as water and amino acids, which these protocells would have naturally encapsulated. The result would then be ready-made melting pots of prebiotic goop ready to seed the Earth, or any other body that passes by.

None of this ultimately answers the question of how life began on Earth. But the work does show that there is no longer any mystery about where the building blocks of life might have come from. "These results indicate that ethanolamine forms efficiently in space and, if delivered onto early Earth, it could have contributed to the assembling and early evolution of primitive membranes.," say Rivilla and co. The question now is: what happened next? By: The Physics arXiv Blog

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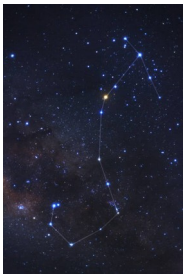
DID YOU KNOW?

Zodiac constellations 16: Scorpius



The 33rd largest constellation, is a prominent eponymous feature, visible in the winter night sky from the southern hemisphere. Its name, the Latin for 'scorpion' is hardly surprising. It is an ancient constellation, possibly because of easily recognisable shape.

In Babylonian astronomy, then name for the scorpion constellation meant 'the creature with a burning sting'. Then astronomers saw adjacent Libra as the scorpion's claws. Greek myths usually contain references to Orion, the hunter, with the scorpion being the animal which stung Orion to death. In one such myth, Orion boasted to the goddess Artemis and her mother, Leto, that he would kill every animal on Earth. Although also a hunter, Artemis promised to protect the animals, and sent a scorpion to deal with Orion. In recognition of this feat, Zeus raised scorpion to heaven. Then, at Artemis's request, he did same with Orion to remind mortals to curb excessive pride.

Another myth relates that Orion knew he was a better hunter than Artemis. However, he said she was the stronger, in order to curry favour with Artemis. Apollo, Artemis's twin brother, resented this and sent the scorpion to attach Orion. After Orion was killed, Artemis asked Zeus to put him in the sky. Every winter Orion hunts in sky, but every summer flees as scorpion constellation comes into sight. In the southern hemisphere, Orion hunts during the summer, but flees in winter as Scorpius comes into sight. During Roman times, the link between Socrpius and Libra weakened, and it became linked with Virgo as the scales of justice. Predictably, Scorpius was one of Ptolemy's 48 constellations.

The Sun passes through Scorpius for around one week, at the end of November. The scorpion's heart is marked by red Antares. Its tail extends into the rich area of the Milky Way, towards centre of galaxy. This alignment means that the constellation features numerous deep-sky objects. There are four Messier objects and numerous NGC objects which can be observed. At least 14 stars in Scorpius are known to have exoplanets.

Notable features include:

- Alpha Scorpii (Antares - 'rival of Mars' as it has a similar reddish colour): this red supergiant is hundreds of times larger than the Sun. Its brightness fluctuates every 405 year from magnitude 0.9 to 1.2.
- M4: a large, loosely scatter globular cluster near Antares, 7,000 ly away, it is one of the closest globular clusters. It is visible through binoculars.
- M7 (Ptolemy cluster): an open cluster. Although visible to the naked eye, it is best viewed through binoculars.

- M6 (Butterfly cluster): an open cluster which appears smaller than M7 because it is twice as distant. It is named for its butterfly shape with two 'wings'. It is visible through binoculars.
- M80: a globular cluster further away than M4 from Antares towards the head of scorpion It was discovered in 1781 by the French astronomer Charles Messier. It has a very dense nucleus. In 1860, it was the site of rare discovery by von Auwers of the nova T Scorpii.
- NGC 6302 (Bug Nebula): a bipolar planetary nebula, about 6,500 ly away.
- NGC 6334 (Cat's Paw Nebula): an emission nebula and star forming region
- Scorpius X-1: the brightest persistent X-ray source in sky, In 1962, it became the first known celestial X-ray source after the Sun. It was discovered during a sounding-rocket flight. It is a low mass X-ray binary with 1an 8.9 hr orbital period. Its counterpart is a visible blue star 9,000ly away. X-rays arise from transfer of material from this to its companion neutron star via an accretion disk. It is over 3 times brighter at X-ray wavelengths than 2nd brightest constant X-ray source, the Crab Pulsar.

Sources: Ridpath, I (Ed) 2012 Oxford dictionary or astronomy Oxford, OUP, Ridpath, I (Ed) 2006 Astronomy London, Dorling Kinderslety, en.wikipedia.org

For more information on the Hermanus Astronomy Centre and its activities, vvisit our website at www.hermanusastronomy.co.za

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