"The Southern Cross"

HERMANUS ASTRONOMY CENTRE NEWSLETTER

SEPTEMBER 2018

Monthly meeting This month's meeting will place on **Monday 17 September** at the **Catholic Church Hall** starting at **19.00**. Dr David Buckley from the SAAO in Cape Town will be talking on 'Gravitational waves: the new frontier in astronomy'. See below for more details.

Stargazing A public event is scheduled to take place on **Friday 14 September** or **Saturday 15 September**, weather permitting. Details, including venue and time, will be circulated to members closer to the time

WHAT'S UP?

Comet 21P/ Giacobini-Zinner Although comet visibility is unpredictable, there is a strong likelihood that, this month, night owls may be able to see this comet with the naked eye. Comets are small bodies of ice and dust which originated in the outer parts of the solar system like the Kuiper Belt and Oort Cloud. Perturbed by the gravitational effects of passing stars, they move into new orbits which bring them into the inner solar system. If their large elliptical orbits come near to Earth, they can be observed as they pass towards or away from the Sun. A short-period comet (those with an orbital period of under 30 years), Comet 21P/ Giacobini-Zinner has a period of 6.5 years.

First discovered, in 1900, by the French astronomer Michael Giocobini, it was re-discovered by the German Ernst Zinner, in 1913. Its closest approach to Earth will be in the early hours of the 11th (around 03.00), moving south through Gemini and Monoceros, when it should, at least, be visible with binoculars. Like all comets, its apparent brightness will be lower than a similar stellar magnitude, because its value is the total for the coma while the actual brightness is stretched out across the whole diameter of the comet. It is the parent body of the Giacobinid meteor shower. Also known as the Draconids, because the radiant lies near Beta Draconis in the northern dragon constellation Draco, these showers only occur intermittently, depending on when Earth's orbit intersects with that of the comet.

LAST MONTH'S ACTIVITIES

Monthly centre meeting At the meeting held on 20 August, Centre member, John Saunders gave a very enjoyable presentation on 'A journey into our weird and wonderful Universe'. Starting inside the solar system and making his way ever further away from us, John showed many images of interesting and beautiful celestial objects. These ranged from unusual lozenge and potato shaped asteroids in the asteroid belt, to the large diversity of the surfaces of the moons of Mars and the 4 gas planets, to star clusters, stellar nurseries, nebulae, planetary nebulae and galaxies. He ended with the recent image of the most distant photographed galaxy, which is 13.3 billion light years away.

It was very pleasant to be able to sit back and enjoy a range of the images which the Hubble Telescope, land-based telescopes and numerous spacecraft have been able to observe and record, enabling us to marvel at the huge variety, colour and nature of the celestial objects found in the Universe. Almost all the images came from the archives of NASA's 'Astronomy image of the day' website, which John visits daily. Having seen his presentation, others, who do not already do so, may well be doing the same in future

Interest groups

Cosmology At the meeting on 6 August, Pierre Hugo gave an introduction to the new series on 'Natural philosophy: science for non-scientists' After giving an overview of the current state of knowledge and understanding within cosmology, he then listed the areas eg dark matter which are little understood/ He also explained how there are some who challenge some of the conclusions which underpin the current Standard Model. After outlining the topics to be covered during the series, he led a lively discussion on the nature of space.

Astro-photography Those who attended the meeting on 13 August discussed processing of an image of the Milky Way taken by one of the group members.

Other activities

Whale Talk article An article bu Jenny Morris titled 'Invisible monsters in space' was published in the August/September 2018 issue of the magazine.

Educational outreach
Hawston Secondary School Space Cadets Weekly meetings resumed in August.
Lukhanyo Youth Club Work continues to erect an analemmatic sundial at this, and other schools in the Overstarand.

THIS MONTH'S ACTIVITIES

Monthly centre meeting This month's meeting, will take place on **Monday 17 September** at the **Catholic Hall** starting at **19.00**. Dr David Buckley from the SAAO in Cape Town will be talking on the very topical subject of 'Gravitational waves: the new frontier in astronomy'. He has been an astronomer at SAAO since 1992. From 1998-2005, he was the SALT Project Scientist during the construction phase. From 2005-2015, he held the positions of SALT Astronomy Operations manager and SALT Science Director.

Summary of the talk 'The first detection of gravitational waves, long predicted from Einstein's general theory of relativity, was made on 14 September 2015, heralding a new frontier of exploration of the Universe. This event was the result of two coalescing black holes, apart from the detection by two gravitational wave "telescopes" in the US, no other signs of the event were detected across the electromagnetic spectrum covered by conventional telescope (e.g. radio, infrared, optical, X-ray, gamma-ray), as was predicted by theory. Since then, a further five events, all black hole mergers, have been detected, again with no electromagnetic counterparts detected.

Then on 17 August 2017, a new type of gravitational wave source, associated with a merger of a pair of neutron stars in a relatively nearby galaxy, was detected. For the first time, a counterpart, resulting from an explosive and energetic kilonova, was promptly detected in gamma rays, ultraviolet, optical and infrared and later at other wavelengths (radio and X-rays). Southern African Large Telescope and other telescopes at the SA Astronomical Observatory were some of the first to observe this unique event as part of an unprecedented international campaign involving dozens of telescopes and over 3500 astronomers'.

There is an entrance fee of R10 per person for members, R20 per person for non-members, and R10 for children, students and U3A members.

Interest group meetings

The **Cosmology** group meets on the first Monday of each month at 19.00. The next meeting will take place on **3 September** at the **Catholic Hall**, starting at **19.00**. Information and discussion on the nature of space will continue in the second meeting in the series on 'Natural philosophy: science for the non-scientist'

There is an entrance fee of R10 per person for members, R20 per person for non-members, and R10 for children, students and U3A members. For further information on these meetings, or any of the group's activities, please contact Pierre Hugo at pierre@hermanus.co.za

Astro-photography This group meets on the second Monday of each month. The next meeting is on **10 September.** Members will continue work on astro-image processing.

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

Stargazing A public event is planned for Friday 14 September of Saturday 15 September, weather permitting. Details, including venue and time, will be circulated closer to the time.

Hermanus Youth Robotic Telescope Interest Group Organisers are progressing with work towards enabling learners to take and process images themselves.

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

FUTURE ACTIVITIES

Cederberg trip The 12-14 October trip to the Cederberg is fully booked. Please contact John Saunders at antares@hermanus.co.za with any queries.

2018 MONTHLY MEETINGS

Unless stated otherwise, meetings take place on the **third Monday** of each month at the **Catholic Church Hall**, beginning at **19.00**. Details for the first few months are:

17 September	'Gravitational waves: the new frontier in astronomy' Presenter: Dr David Buckley, SAAO, Cape Town
22 October	'The Fermi paradox and its implications for extraterrestrial life' Presenter: Johan Retief, Centre member
19 November	'Table Mountains: geology and astronomy' Presenter: Jenny Morris, Centre member
10 December	Xmas party

ASTRONOMY EDUCATION CENTRE AND AMPHITHEATRE (AECA)

A decision by the Council of Overstrand Municipality on the planning application continues to be awaited. In the meantime, the Friends of the Observatory pledge fund continues to be an important source of funds to cover associated costs.

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, something which is still awaited.

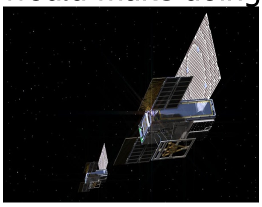
We would, therefore, be very grateful if members could either continue to contribute to the campaign or start becoming a contributor. Both single donations and small, regular monthly donations, of any amount, are welcome. Contributions can take the form of cash (paid at meetings), or online transfer,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

First interplanetary CubeSat mission, MarCO, is only the beginning 7 August: When the InSight lander began its journey to Mars on 5 May, two tiny satellites tagged along for the ride - CubeSats called MarCO-A and MarCO-B. CubeSats are a small and relatively inexpensive type of spacecraft, and they tend to use off-the shelf technologies. In recent years, dozens of them have been launched into low-Earth orbit by scientists, students, and businesses alike. The MarCOs, however, are the first CubeSats to travel into deep space, and they could pave the way for a new generation of small spacecraft that would make doing interplanetary space science much more accessible.


The twin MarCO CubeSats launched May 5th with NASA's larger InSight mission, NASA/JPL-Caltech

The Mars Cube One (MarCO) satellites themselves are mostly flying to test the technologies that could take CubeSats beyond Earth orbit. Bruce Banerdt, a research scientist at NASA's Jet Propulsion Laboratory (JPL), calls them "an interesting and cool piggyback to our mission," but notes that they will not affect the core science that InSight will perform. If the MarCOs make it to Mars, they will relay communications from InSight as it lands in real time, but what really matters is the knowledge they will provide on what it takes to send small spacecraft on interplanetary missions.

There are already teams working on concepts and designs for future CubeSats and small spacecraft that will go on interplanetary missions, and they are watching how well the MarCOs survive heat and radiation, how successfully they can communicate, and how well they deal with the propulsion and navigation challenges of their mission.

The MarCOs will face many challenges between Earth and Mars. "Deep space is a very unforgiving environment," says Joel Steinkraus, MarCO lead mechanical engineer at JPL. The success CubeSats have had in Earth orbit often cannot be replicated directly in deep space, he explains. For example, when orbiting Earth, a CubeSat can communicate with any number of stations on the ground. As it leaves orbit, however, those opportunities drop off very quickly. The MarCOs will address this problem by testing a new radio: a miniaturised version of the Iris radio used by larger spacecraft. About the size of a softball, the radio will allow the MarCOs to communicate with the Deep Space Network (DSN) - an array of giant radio antennas placed at strategic locations around the Earth. It is only recently, Steinkraus says, that it has been possible to manufacture components for a radio small enough for the MarCOs to carry, but powerful enough to reach the DSN.

Then there are the extreme conditions in deep space. Steinkraus says, "We designed a single outfit so MarCO could run a marathon in the Sahara while snowshoeing in the Arctic at the same time," referring to the vast temperature variations that the spacecraft will encounter. Aside from heat and cold, deep space has a different radiation environment than is found in Earth orbit. Steinkraus notes that high-energy particles can easily flip bits and affect transistors, so the CubeSats' systems need to understand and detect faults when they occur. Deep space will also test the MarCOs' ability to propel and orient themselves. About half of each MarCO spacecraft consists of a propulsion system, Steinkraus says. The CubeSats are stocked with compressed R236FA gas, a propellant commonly used by fire extinguishers. However, they won't have the same navigation tools available to CubeSats in Earth orbit. Without GPS or a nearby planetary body, they will rely on tracking the positions of the stars and the Sun to know exactly where they are and where they are going.

Finally, powering all these functions takes a lot of energy as well. Steinkraus explains that the farther the MarCOs get from the Sun, the less energy their solar arrays will be able to collect. The CubeSats are designed to subsist on a "low-calorie diet of photons", storing excess energy along the way so there will be enough juice on hand when it's time to relay data from Mars to Earth.

Even if the MarCOs prove that CubeSats can function beyond Earth orbit, they are not likely to replace larger spacecraft. "CubeSats are very good at performing very specific tasks and being very focused," says Steinkraus. However, they are much too limited to handle complex missions on their own. When they can fly solo, CubeSats and other small satellites could have a major impact on space science by filling in key gaps in data. For example, Valeria Cottini, an associate research scientist at the University of Maryland and principal investigator for the CubeSat UV Experiment, is working on a mission concept for a CubeSat that would travel to Venus to investigate its atmosphere. For decades, planetary scientists have wrestled with questions about mysterious stripes that appear in Venus's cloud layer when viewed in ultraviolet. Waiting for the next big mission to Venus could mean going without new data for 10 years or more. However, Cottini's CubeSat concept would provide a relatively cheap and feasible way to fill in information on the Venusian cloud tops. In general, she says, CubeSats could be complementary to larger missions and enable science that would otherwise be impossible due to time, money, or risk constraints.

By: Erica Naone

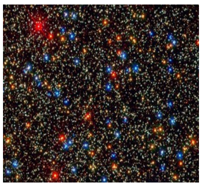
Why is Europa whistling? 8 August: Some of Jupiter's moons 'hum'. New research details the discovery of 'whistler' radio waves coming from two of the moons: Ganymede and Europa. The other two large moons, Io and Callisto, are not subject to this phenomenon. The finding is interesting because both Europa and Ganymede - the largest moon in the solar system - have subsurface oceans.


Jupiter's moons put out "whistler" radio waves. Future spacecraft could help unravel their cause. ESA/NASA, Artist M. Carroll

In the rest of the solar system, these kinds of whistler waves have various causes. On Earth, the 'hum of the whistlers - which translate to sound you can hear when properly processed - are caused by the Van Allen radiation belts. Earth's radiation belts accelerate the particles to high energies, something not seen in the Jupiter data. On Jupiter, they are produced by massive lightning storms.

The astronomers used data from NASA's now-defunct Galileo space probe, which explored Jupiter and its moons from 1995 to 2003. That means the data is old and at times incomplete. It also makes it impossible to follow up on what's causing the whistler waves. However, the existing data suggest that both Europa and Ganymede have some kind of magnetic field coming from within them. These magnetic fields would vie against the massive magnetic field of Jupiter, providing an interesting environment far different than the interactions between Earth and the Sun's magnetic fields. By: John Wenz

Neighbouring Omega Centauri is probably uninhabitable 10 August: Astronomers have long held out hope that Omega Centauri, a massive globular cluster just 16,000 light years away, harbours habitable exoplanets. Researchers estimate that 10 million densely packed stars lie within the cluster's borders, so statistically speaking, it must house *some* habitable planets, right? Wrong. In fact, Omega Centauri's stellar density is the reason why some scientists now suspect life does not exist on any of its planets.


A close-up of Omega Centauri's core shows some of the 10 million stars that lie within its borders. NASA, ESA, and the Hubble SM4 ERO Team

"Despite the large number of stars concentrated in Omega Centauri's core, the prevalence of exoplanets remains somewhat unknown," said researcher Stephen Kane, who teaches planetary astrophysics at the University of California, Riverside. "However, since this type of compact star cluster exists across the universe, it is an intriguing place to look for habitability." Kane, and San Francisco State graduate student Sarah Deveny, used data from the Hubble Space Telescope to study 350,000 red dwarfs in the centre of Omega Centauri. These stars are around the right age and temperature for exoplanets to exist within their habitable zones - the region where liquid water can be sustained on a planet's surface.

The duo calculated the habitable zone for each of these stars and found that, like the cluster itself, it is a pretty tight squeeze. Due to the small and dim nature of red dwarfs, they give off little light and have habitable zones that only stretch about 74 million km from their surfaces. That is just half the size of habitable zones surrounding stars like the Sun.The short distance between red dwarfs and their potentially habitable planets isn't an issue, but their proximity to *other* red dwarfs is.

In the core of Omega Centuari, only about 0.16 light years lie between each red dwarf. For comparison, the closest star to our Sun is Alpha Centauri, which sits a good 4.22 light years away. Since the stars are so compact, their gravitational forces end up interacting with one another, and consequently knocking each other's planets out of orbit. The researchers estimate that these stars disrupt each other once every 1 million years or so, not giving their planets enough time to form and sustain life. By: Amber Jorgenson

How NASA protects its solar probe from the Sun 10 August: Over decades of spaceflight, we have sent probes to Mars, Saturn and even our beloved dwarf planet Pluto – uncovering the mysteries of the planets of our solar system. Meanwhile, the star at the heart of it all has remained unprobed. That's about to change. NASA's Parker Solar Probe will launch as soon as 11 August. And, over the course of a seven year mission, it will orbit the Sun two dozen times, with its final three orbits coming as close as 6.24 million km from our star's surface. This is some 4 percent the distance between Earth and the Sun.

Johns Hopkins University Applied Physics Laboratory

"[Parker] will not only make history by answering questions that have puzzled scientists for decades, but it may also lead to the discovery of new phenomena that are completely unknown to us now," says Nour Raouafi, Parker Solar Probe Deputy Project Scientist. "This mission has the potential to steer solar and heliospheric research into a new direction." Using Parker, scientists hope to unravel some of the outstanding mysteries surrounding the star of our solar system. Chief among those is why its outer atmosphere, called the corona, can reach scalding hot temperatures of some 2 million degrees Celsius, while 1,600km below, the surface of the Sun is relatively 'cool' at 5,500°C.

"The spacecraft and most of the payload will be protected by a shield from the Sun's heat, which will be as high as 500 times what we experience at Earth," Raouafi says. The heatshield, made of carbon composites, must be positioned between the spacecraft and the Sun's corona at all times during close encounters. If the shield is misaligned even briefly, the probe will melt in a matter of seconds. Why will carbon not melt under such extreme temperatures? The reason boils down to a fundamental difference between heat and temperature. Temperature describes the kinetic energy of molecules, so higher temperatures mean molecules move faster. Heat is the transfer of energy between molecules. Just outside the Sun's atmosphere lies the emptiness of space. Here there are few molecules to collide with Parker's Sun shield and transfer heat to the device. NASA predicts the shield will only reach temperatures of 2,500°C. While on the other side of the 12cm thick carbon shield, the body of the spacecraft will sit at a comfortable 30°C.

Parker has four different instruments, which will analyse the Sun's electric and magnetic fields, plasma, and energetic particles, as well as image its solar wind. The only instruments that must brave the heat of the Sun, protruding from behind the safety of the shield, are electric field antennas and a small plasma detector. The wires of these tools are crafted from robust niobium, and encased in a protective layer of sapphire crystal tubes.

Besides exploring the curious temperature differences between the Sun's surface and corona, scientists are particularly keen to understand what accelerates solar wind (made up of charged particles emitted from the Sun, like protons and electrons). When the particles are spewed toward Earth with sufficient strength, the effect can disrupt radio communications, harm satellites, and in extreme cases, interfere with power grids. Solar wind can reach speeds of 2.9 million km per hour, but how the particles are accelerated to such speeds remains a mystery. "The state of solar wind is greatly affected during its journey toward Earth and beyond by a number of other physical processes, which mask completely what caused the heating and acceleration of the plasma in the corona in the first place," Raouafi says. "There is no better solution than diving in the corona to gather the data we need to understand how it works." By: Michelle Hampson

Magnetic fields may be to blame for Jupiter's skin-deep stripes 15 August: The Great Red Spot might be Jupiter's most famous feature, but the giant planet would be unrecognisable without the multicoloured bands streaking across its face. The colours are there thanks to the chemistry of Jupiter's atmosphere, but the striped pattern itself comes from long-lived winds called zonal flows that blow east-west around the planet in alternating directions. These zonal flows are similar to the jet streams high in Earth's atmosphere.


Jupiter's signature stripes. NASA/JPL-Caltech/SwRI/MSSS/Kevin M. Gill

Unlike Earth, Jupiter does not have geographical features like mountains interrupting these winds, so the zonal flows stream in (mostly) smooth lines, making the stripes we know and love. For a long time, scientists debated how deep into the planet these striped features might extend. Were the zonal flows only on the surface of Jupiter, or did deeper layers of gas flow in stripes of alternating directions too? Part of the mystery was solved earlier this year when detailed observations from NASA's Juno's mission revealed that the zonal flows are roughly 3,000km - about 4 percent of Jupiter's radius — deep. Below that, the gases that make up Jupiter rotate as a single cohesive object.

In the study, physicists Jeffrey Parker and Navid Constantinou calculated how magnetic fields could prevent these zonal flows from forming deep within rotating spheres of fluid – like those on the gaseous giant Jupiter. In the past, simulations have shown that magnetic fields can discourage zonal flows, but Parker and Constantinou have now explained in detail the physical mechanisms of the effect. "The zonal flows themselves have a really large effect on the dynamics of the planet," Parker says. "So understanding the zonal flows in Jupiter tells us a lot about the planet. And the interior has really been a mystery so far. Any understanding of the interior is very new."

To nail down whether the newly described mechanisms are in fact responsible for the lack of zonal flows within Jupiter, the researchers plan to work with scientists running NASA's

Juno mission. That should allow them to compare their theory to the observations in much greater detail. By: Erica K Carlson

Multiple 'mini-moons' could be orbiting Earth 15 August: Researchers have theorised the existence of 'mini-moons' - tiny asteroids pulled into Earth's orbit by forces of gravity - ever since discovering one with NASA's Catalina Sky Survey in 2006. These fast-moving asteroids revolve around the planet before either falling toward the surface as a meteor, or being ejected back out into space. However, because of their small size and quick movements, no mini-moons have been detected since, leading many to wonder if more actually exist.


ESA – P.Carril

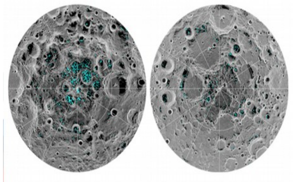
The upcoming Large Sybnoptic Survey Telescope (LSST) is going to hunt down and track the orbits of these hidden visitors, giving insight into the mysterious nature of asteroids and their journeys through space. The mini-moons are likely to be only a few metres long and typically come from the asteroid belt between Mars and Jupiter. The gravitational pull of the Sun and the inner solar system's planets likely gradually draws the mini-moons out of the belt, allowing Earth to capture them as they pass by.

Some end up making multiple trips around the planet, while others only make a partial revolution. Regardless of their trajectory, they meet with one of two fates: plummeting to Earth and disintegrating in its atmosphere, or escaping its gravitational pull. Whatever end they come to, the average mini-moon is thought to only spend about 9 months in Earth's orbit. It might not seem like long, but it gives us plenty of time to conduct some science.

"At present we don't fully understand what asteroids are made of," said Mikael Granvik of the Luleå University of Technology, Sweden and the University of Helsinki, Finland. "Missions typically return only tiny amounts of material to Earth. Meteorites provide an indirect way of analysing asteroids, but Earth's atmosphere destroys weak materials when they pass through." With the help of the LSST, both of these setbacks could be evaded. The high-powered telescope, set to launch in 2022, will be equipped with a wide field camera, capable of surveying the whole sky once every week, and an 8-meter mirror that will pick up the subtle light given off by mini-moons, allowing researchers to easily locate them and track their orbits.

"Once we start finding mini-moons at a greater rate they will be perfect targets for satellite missions. We can launch short and therefore cheaper missions, using them as testbeds for larger space missions and providing an opportunity for the fledgling asteroid mining industry to test their technology," said Robert Jedicke of the University of Hawaii, Honolulu. Since these satellite missions would bring asteroids to Earth in shielded spacecraft, they would not be damaged or stripped of any materials when they pass through the atmosphere. Being able to study larger asteroid samples in their natural states would help shed light on their compositions, the conditions that they formed in and how they've evolved since. By: Amber Jorgenson

There is definitely ice on the surface of the Moon 21 August: Research shows that specific signatures of water ice exist atop the cold, dark craters near the Moon's poles - proving the existence of lunar surface ice for the first time.



The concentration of water ice on the lunar surface. The south pole and its hefty concentration of ice within craters is shown on the left, and the right shows the more sporadic, wide spread ice on the north pole. NASA

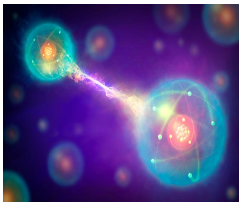
This story probably sounds familiar, and that is because it is not the first time we have found water particles on the Moon. Water was detected back in 2009 when NASA's Lunar CRater Observation and Sensing Satellite (LCROSS) shot into the south pole's Ceabeus crater and exposed its subsurface. This proved that water exists within the Moon, but not necessarily on the Moon's surface. Other instruments have also detected reflective surfaces that resemble surface ice, but things like reflective soil could easily explain that away, rendering the findings inconclusive.

To finally get some hard evidence, a group of scientists looked back at data from NASA's Moon Mineralogy Mapper (M3), a visible and infrared spectrometer that rode aboard India's Chandrayaan-1 orbiter during its 2008-2009 tour. M3 was capable of directly measuring how molecules on the Moon's surface absorb infrared light, which distinguishes surface ice from liquid water, water that's held in minerals and water that is hidden under the surface. It was also able to detect the specific reflective properties that are often given off by surface ice. When they combined these two factors, they found reflective properties, as well as definitive interactions between molecules and infrared light, that indicate the presence of water ice on the lunar surface. The Moon's south pole showed high concentrations of ice in lunar craters, whereas the north pole's ice was more spread out across the surface.

Why ice was found congregating near the poles and in craters is not a complete mystery, either. Deep, frigid craters are often referred to as 'cold traps' - areas so cold that water vapour inside them freezes and is unable to escape for significant periods of time, possibly billions of years. Due to the Moon's tilt and rotation, the cold traps near the poles are shielded from direct sunlight and only reach -121°C. Compared to the maximum equatorial temperatures of 126Celsius), the cold, polar basins are more likely to hold on to water.

This is good news for astronauts. The surface ice might be easier to access than underground water, which could be useful in future manned missions. The amount of surface ice is unknown, but if there's enough, missions could potentially use it as drinking water, convert it to oxygen for breathing, or use it as rocket fuel by converting it to oxygen and hydrogen. There is still a lot we don't know about the newfound surface ice, but further exploration could help us understand how it got there, and what its role was in the Moon's mysterious formation and evolution. By: Amber Jorgenson

Quantum entanglement loophole quashed by quasar light 23 August: With the help of two extremely bright quasars located more than 7 billion light-years away, researchers recently bolstered the case fo quantum entanglement, a phenomenon Einstein described as "spooky action at a distance", by eliminating one classical alternative: The freedom-of-choice loophole.


Quantum entanglement is a bizarre offshoot of quantum mechanics that says two particles can instantly communicate with one another, even across cosmic distances. Mark Garlick/Science Photo Library/Alamy Stock Photo

Of the many mindboggling facets of quantum mechanics, one of the most intriguing is the idea of quantum entanglement. This occurs when two particles are inextricably linked together no matter their separation from one another. Although these entangled particles are not physically connected, they still are able to share information with each other instantaneously - seemingly breaking one of the most hard-and-fast rules of physics: No information can be transmitted faster than the speed of light.

As far-out as the idea seems, quantum entanglement has been proven time and time again over the years. When researchers create two entangled particles and independently measure their properties, they find that the outcome of one measurement influences the observed properties of the other particle. However, what if the apparent relationship between particles is not due to quantum entanglement, but instead is a result of some hidden, classical law of physics? In 1964, physicist John Bell addressed this question by calculating a theoretical limit beyond which correlations can only be explained by quantum entanglement, not classical physics. However, as is often the case, there are loopholes.

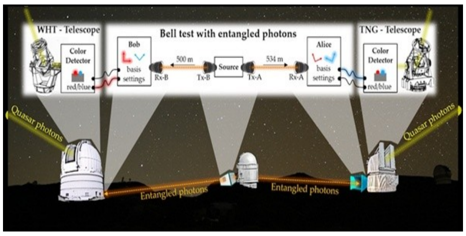
One of the most stubborn of these loopholes is the so-called 'freedom-of-choice' loophole, which suggests a hidden classical variable can influence how an experimenter decides to measure seemingly entangled particles. This causes the particles to appear quantumly correlated even when they are not.

To help constrain the impact of the freedom-of-choice loophole, the authors of the new study used extremely distant quasars (exceptionally bright and energetic galactic cores) to decide which properties of entangled particles to measure. By allowing the quasars' light to 'choose' what properties to measure, the researchers effectively removed the freedom-of-choice loophole from the experiment. This is because the quasars are located 7.8 and 12.2 billion light-years away, so their observed light was emitted billions of years before the researchers even conceived of the experiment.

"If some conspiracy is happening to simulate quantum mechanics by a mechanism that is actually classical, that mechanism would have had to begin its operations - somehow knowing exactly when, where, and how this experiment was going to be done - at least 7.8 billion years ago," said co-autho Alan Guth, a physics professor at MIT. "That seems incredibly implausible, so we have very strong evidence that quantum mechanics is the right explanation." According to Guth, the probability that a classical process could explain their results is about 10-20, or 1 in 100 billion billion.

"The Earth is about 4.5 billion years old, so any alternative mechanism - different from quantum mechanics - that might have produced our results by exploiting this loophole would’ve had to be in place long before even there was a planet Earth," adds David Kaiser of MIT. “So we’ve pushed any alternative explanations back to very early in cosmic history.”

To carry out the study, the team utilized two 4-meter-wide telescopes - the William Herschel Telescope and the Telescopio Nazionale Galileo - located just over 1 km apart on a mountain in La Palma, Spain. Both telescopes were trained on different quasars located billions of light-years away. Meanwhile, at a station between these two telescopes, the researchers generated pairs of seemingly entangled photons - or particles of light - and beamed one member of each pair to a detector at each telescope. As the entangled photons travelled to the detectors, the telescopes analysed light from the quasars and determined whether the light was more red or more blue than a baseline.



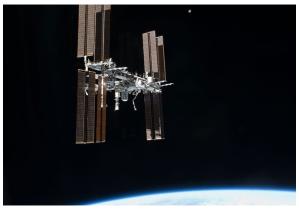
The experimental set-up used to test the freedom-of-choice loophole. D. Rauch et al. (Phys. Rev. Lett. 121, 080403)

Depending on the measurement, the entangled-photon detectors automatically adjusted the angle of their polarisers, which are devices that measure the orientations of photon electric fields. This allowed the researchers to test whether the photon pairs were truly linked to one another, or if they were just faking it. Over the course of two 15-minutes experiments (each utilising two different pairs of quasars), the researchers measured over 17,000 and 12,000 pairs of entangled photons, respectively. According to the study, the results show it is extremely unlikely a classical mechanism is responsible for the strong correlations observed between the photon pairs, meaning the photon pairs truly were quantumly entangled.

This experiment is not the first time the freedom-of-choice loophole has been tested. Last February, the same team of researchers led a similar study that used 600-year-old starlight to determine which photon properties to measure. Although the new research uses light that is nearly 8 billion years older, there still remains a small window of time for the freedom-of-choice loophole to slip through. In order to close this window completely, the researchers are already planning to look back even further in cosmic time, concentrating on the earliest light in the universe - photons from the cosmic microwave background.

By: Jake Parks

The International Space Station is losing air to a tiny hole, astronauts safe 30 August: Early this morning, NASA announced that the International Space Station - one of the most expensive and complex structures ever built - is slowly leaking air out of miniscule hole just 2 millimetres wide. Although the astronauts aboard are not currently in danger, this is the first time the nearly 20-year-old orbiting laboratory has experienced any potentially hazardous damage.

 The International Space Station orbits some 400km above Earth's surface, and is routinely exposed to impacts by tiny, fast-moving objects like paint chips, often leaving marks on the outside of the station's hull. NASA/JPL-Caltech

Flight controllers first recognized the leak on Wednesday night (29 August), but determined it was so small it posed no immediate threat to the six astronauts aboard the station, opting to let them sleep as normal. When the crew awoke this morning, mission controllers both in Houston and outside of Moscow attempted to pinpoint the leak. All six astronauts joined in the hunt, closing off individual modules within the station to better locate the source. After an extensive search, the crew traced the leak back to the crew capsule of the Russian Soyuz MS-09 spacecraft, which shuttled three astronauts to the station in June. Although European Space Agency (ESA) astronaut Alexander Gerst initially plugged the leaking hole with his thumb, temporarily stabilising the pressure, the hole was eventually covered with Kapton tape, which is often used in spacecraft due to its ability to function across a very wide range of temperatures.

Both American and Russian mission controllers, as well as all six astronauts, are still attempting to permanently seal the leak. According to Stephen Clark's live blog for spaceflightnow.com, "Russian mission control wants the crew to use a wipe saturated in sealant to plug the tiny, 2-millimetre opening on the hull of the Soyuz spacecraft's orbital module." However, the amount of air being lost continues to fluctuate, and if the hole is not entirely patched in the next few days, some crew members may need to depart the station and return to Earth earlier than planned. (The Soyuz spacecraft's orbital module is not required for re-entry into Earth's atmosphere.)

Although officials have not yet determined exactly what caused the leak, a leading theory is that a tiny, speeding piece of space junk struck the station. These strikes are not unheard of. In fact, in 2016, ESA astronaut Tim Peake captured a 7-millimetre-wide chip in one of the stations windows. At the time, Peake said "I am often asked if the International Space Station is hit by space debris. Yes - this is the chip in one of our Cupola windows, glad it is quadruple glazed!"

By: Jake Parks

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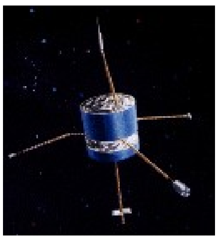
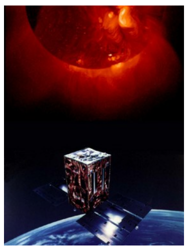
DID YOU KNOW?

The Sun Part 30: **Solar exploration 1**



Pioneer 6 spacecraft

Solar Maximum Mission



Yohkoh satellite

Solar observation and investigation from Earth has taken place for centuries, and there are a number of dedicated solar observatories in several countries. Deeper knowledge of the Sun has also, and continues, to be obtained from space missions. From 1959-1968, NASA's Pioneer 5, 6, 7, 8 and 9 were the first satellites designed to observe the Sun from space. Orbiting at distances similar to that of Earth, they made the first detailed measurements of the solar wind and the solar magnetic field. Pioneer 9 was the most successful, transmitting data until May 1983.

In the 1070s, the two German Helios probes, launched by NASA, studied the Sun and interplanetary space from well inside Mercury's orbit. Helios 1, launched in 1974, was put into an orbit only 45 million km from the Sun at perihelion, closer than any previous probe. In 1976, Helios 2 orbited as close as 43 million km as it also studied the Sun and interplanetary space. NASA's Skylab, launched in 1973, included a solar observatory, the Apollo Telescope Mount. This contained six telescopes for observing the Sun's chromosphere and corona at X-ray, ultraviolet and visible wavelengths. The on-board astronomers made the first time-resolved observations of the solar transition region and ultraviolet emissions from the corona. Discoveries included first observations above coronal mass ejections and coronal holes, the latter now known to be associated with solar wind.

In 1980, NASA launched the Solar Maximum Mission satellite. It was designed to observe gamma ray, X-ray and ultraviolet radiation from solar flares during the solar cycle maximum. A few months after launch, electronic failures caused the probe to go into standby mode for three years until, in 1984, the space shuttle Challenger retrieved the satellite, repaired the electronics, and released it back into orbit. The mission then took thousands of images of the corona before re-entering Earth's atmosphere in late 1989.

Japan's Yohkoh satellite was launched in 1991. Meaning 'sunbeam' Yohkoh's four instruments observed solar flares and other solar phenomena at X-ray and gamma ray wavelengths. Data obtained allowed for identification of several types of flares, and showed that the corona away from peak activity regions was much more dynamic and active than previously thought. The satellite observed a full solar cycle, but went into standby mode in 2001 when an annular eclipse caused it to lock onto the Sun. It was destroyed in 2005 during atmospheric re-entry.

Sources: Ridpath, I (Ed) (2012) Oxford dictionary of astronomy 2nd ed rev, www.en.wikipedia.org,

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