"The Southern Cross"

HERMANUS ASTRONOMY CENTRE NEWSLETTER

JANUARY 2018

As the Centre enters its second decade, we wish all our members all the best for 2018.

Monthly meeting

This takes place on **Monday 22 January** at the **Catholic Church Hall** starting at **19.00**. The speaker is Dr Yabebal Fantaye, holder of the ARETÉ Junior Research Chair in Applied Statistical Methods, Cosmology and Big Data based at the Institute for Mathematical Sciences (AIMS) in Cape Town. His talk is titled "How do we measure the size, weight and age of the Universe?' For further details see below.

Membership renewal for 2018

The fees for 2018 are unchanged. They are as follows:

Member: R150

Member's spouse/partner/child, student: R75

Six-month membership from July – December 2017:

Member: R75 Member's spouse etc, student: R40

Payment can be made in cash (at meetings directly to the Treasurer), or via online transfer. The Standard Bank details, for the latter, are as follows:

Account name – Hermanus Astronomy Centre

Account number – 185 562 531

Branch code – 051001

If you make an online donation, please reference your name and 'subs' or 'membership', or it is not possible to attribute the payment to you.

Monthly meeting dates for 2018

Dates for your diaries are: 22 January, 19 February, 19 March, 16 April, 21 May, 19 June, 16 July, 20 August, 17 September, 22 October, 19 November and 10 December.

WHAT'S UP?

Four lunar phenomena The Moon continues to attract interest this month. On 1 and 30 January, the moon will have two properties – a full moon and a supermoon. The full moon on the 30th will also be a blue moon, the name given when a second full moon occurs in a calendar month. Some have described this very rare combination as a super-blue moon. The occurrence of supermoons reflects the fact that the Moon's orbit is a slightly elliptical one. At apogee (furthest point from Earth), the Moon is around

405,500lm from Earth, while, at perigee (closest point to Earth), it is around 363,300km away, a difference of around 43,000km. A full moon is described as a supermoon when its position is 90% or closer to perigee. At perigee, the full moon appears 7-14% bigger than it does at apogee, and up to 30% brighter, depending on how close it is to perigee.

Blue moons occur only every 2-3 years. Their relative rarity led to coining of the phrase 'once in a blue moon'. The term 'blue moon' is also applied to the, usually, even more rare occurrence of a visibly blue-coloured moon. These are caused by the interaction of light with high-altitude soot and other particles produced by large-scale forest fires, which scatter red light preferentially, making the moon appear blue to observers in that area. To add to the complexity, there is also a syzygy ie the linear alignment of any three celestial objects. In this case it is formed by the full Moon, the Sun and Earth. Syzygy also occurs at new Moon.

LAST MONTH'S ACTIVITIES

Monthly centre meeting The annual Christmas party too place at the Catholic Church Hall on 11 December. Jenny Morris reports: "24 members and partners enjoyed a festive evening of fantastic food (catered by CanD's Kitchen), poppers, crackers and entertainment. Centre chairman Pierre de Villiers gave a brief overview of the many activities and events which have taken place since the Centre was founded in December 2007. This was followed by a rolling series of images taken at various events during that time, and a short but important phone call to Steve Kleyn, one of the founder members, who now lives in Cape Town. Once everyone had finished enjoying the excellent finger food and accompanying snacks they embarked on this year's quiz, which was based on HAC activities during the past decade. As usual, there were mutterings that the questions were too difficult etc, but the teams did will, the winners' reward being some Continental chocolates. Many hands made light work of the clearing up. The hall was left with no evidence of our marking the first decade of the HAC, but the attendees took home many reminders and memories of how busy the Centre has been over the years."

Interest groups

Cosmology Those who attended the meeting on 4 December watched another two episodes in the DVD series: Particle Physics for Non-Physicists: a Tour of the Microcosmos' by Prof Steven Pollock, Professor of physics at the University of Colorado at Boulder. These episodes were Lecture 21: 'Back to the future 1 – experiments to come' and Lecture 22: Back to the future 2 – puzzles and progress'

Astro-photography There was no meeting in December.

Other activities

Educational outreach

Hawston Secondary School Astronomy Group Meetings will resume once the new school year has started.

Lukhanyo Youth Club No meetings took place during December.

Stargazing After several delays due to poor weather conditions, the last stargazing event was held on 16 November 2017. Peter Harvey reports: "We have seven members, including Jeff and Denise Hagin with their telescope, and two visitors. We didn't do as well as hoped. We were able to observe Saturn, Mercury and 47 Tucana. We had some visual sightings of the Magellanic Clouds (very obscure), Scorpius and Crux (Southern Cross). The English visitors loved this. The seeing wasn't great and the easterly wind was strong and icy. Although we packed up early, it had still been an interesting evening."

Southern Star party report Bennie Kotze reports on the event which took place from 19-22 October 2017**:** "For the second time this year the venue of the Southern Star Party was at Leeuwenboschfontein Guest Farm, near Robertson. In spite of the barren and arid landscape I was again stunned by the beautiful leaf-green environment, green lawns and the very well-kept camping sites, all evidence that the resort is situated on an aquifer and has some boreholes to tap from it.

On arrival on Thursday afternoon, I took a short break and then went to assist Pierre (de Villiers) to erect his mobile telescope. The sky for the next three nights was absolutely magnificent for stargazing. I was highly impressed by the clarity and the quality of the 60 degrees, 18 mm and 6 element eye-piece I recently bought from eBay. My favorite target, 47 Tucana, I visited many times, as well as the Andromeda galaxy, open clusters, etc. Besides stargazing I could fit in some astro-photography with my Canon 700D under control of Nebulosity. On Saturday evening, at midnight, the Orion constellation rose over the horizon and it looked absolutely magnificent., I was very tempted to haul out my camera and laptop again for a series of photos, but with heavy eyelids after a few late nights viewing, I decided to call it a day.

The highlight of the visit to the SSP, however, is the story of the 14" telescope that was donated to HAC by UCT some two years ago. On arrival it was tested and found to have a problem with its focus and was subsequently stored in a warehouse at Coastal Trusses. An inspection team (Pierre, Derek Duckitt, Deon Krige and I) went for a final inspection to decide on the its destiny. Because of its antiquated appearance, we jokingly suggested it be donated to a museum. Derek, however, was adamant to make an attempt to find the fault and to make it useful again. It was then taken to his home. Well, his perseverance paid off - he discovered a loose screw in the primary mirror area.

He decided to bring it to the SSP and subject it to a proper acid test. We assisted Derek to offload and assemble the mount and to lift the rather heavy telescope onto the mount. During Friday evening he concluded that there was something wrong with the diagonal mirror and eyepiece. On Saturday morning, he took it apart, cleaned it and made some minor adjustments before assembling it again. I am happy to report that we ended our viewing at midnight on a high with a spectacular view of the Orion nebula through the 14". Well done Derek!!"

Whale Talk article An article by Jenny Morris titled 'Hunter in the summer sky' was published in the December 2017-January 2018 issue of the magazine.

THIS MONTH'S ACTIVITIES

Monthly centre meeting This month's meeting will take place on **Monday 22 January** at the **Catholic Hall** starting at **19.00**. Dr Yabebal Fantaye, holder of the ARETÉ Junior Research Chair in Applied Statistical Methods, Cosmology and Big Data based at AIMS in Cape Town will be addressing the question "How do we measure the size, weight and age of the Universe?' Dr Fantaye completed his BSc degree in Physics and Math at Addis Ababa University, Ethiopia, and his Honours and Master's degrees at UCT, through the National Astrophysics and Space Science Program (NASSP). For his PhD, he went to the School for Advanced Studies (SISSA) in Trieste, Italy. Before taking the ARETÉ Chair position in June 2016, he was a postdoctoral researcher for one year at the University of Oslo, Norway, and for three years at the University of Rome Tor Vergata, Italy.

Dr. Fantaye's research is geared towards 'Uniting astronomy and industry through Big Data research', using statistical methods such as Machine Learning to extract insights from astronomical and social Big Data. He says such technologies are imperative for the continent because Africa is actively involved in leading world-class astronomy projects through the SKA and related surveys.

Interest group meetings

The **Cosmology** group meets on the first Monday of each month at 19.00. There is no meeting in January. The next meeting will take place on **5 February** at the **Catholic Hall**, starting at **19.00**.

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 **15 January**.

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

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

For further information on both the MONET and Las Cumbres projects, please contact Deon Krige at deonk@telkomsa.net

FUTURE ACTIVITIES

No trips are being planned, at present.

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:

22 January	'How do we measure the size, weight and age of the Universe?' Presenter: Dr Yabebal Fantaye, AIMS, Cape Town
19 February	AGM
19 March	TBA
16 April	'If you wish to make an apple pie from scratch, you must first invent the Universe' Presenter: Dr Sean February, CSIR
21 May	'Recent and ongoing work on pulsar light curves' Presenter: Andre van Staden

ASTRONOMY EDUCATION CENTRE AND AMPHITHEATRE (AECA)

Consideration of the planning application by the Council of Overstrand Municipality continues to be awaited. Hopefully, the additional information requested by staff will enable this to take place soon. 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.

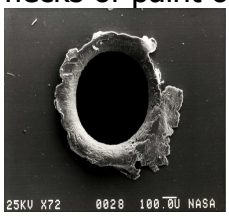
We would, therefore, be very grateful if members could either continue to contribute to the campaign or start becoming a contributor. Both single donations and small, regular monthly donations, of any amount, are welcome. Contributions can take the form of cash (paid at meetings), or online transfer,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

The ISS is getting a small space junk sensor 4 December: The International Space Station (ISS) is about to get a big upgrade to study very tiny bits of space junk floating in Earth orbit. Called the Space Debris Sensor (SDS), the one-square-metre array has a series of microsensors to study what happens when it is struck by objects the size of flecks of paint or other particles less than 10 cm in size.



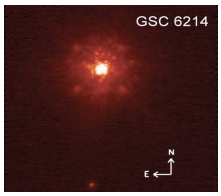
Close-up view of impact left by space debris on the Solar Max experiment. NASA

It is a first step in studying this virtually untrackable space debris population. Figuring out where the majority of small space junk and micrometeoroids reside will enable design of safe future spacecraft orbits. It could also help figure out how best to shield a craft to avoid a fatal event if an errant screw strikes it at high speed. By: John Wenz

Oversized planet or undersized star? 5 December: Taking a picture of an exoplanet is a bit like taking a picture of a firefly next to a spotlight. Although an exoplanet emits light, that light is almost completely washed out by the brightness of its host star. Despite this problem, astronomers have still managed to snap images of about 20 large planet-like bodies orbiting other stars. These celestial objects, known as planetary-mass companions, possess three traits that make them well suited for imaging — they are more massive than Jupiter, they orbit very far from their host stars, and they are relatively young, so they are still glowing with heat from their initial formation. Though researchers are making headway imaging planetary-mass companions, one fundamental question still remains: Are these companions actually exoplanets, or could they instead be 'failed stars' called brown dwarfs?

To help address this question, a team of astronomers from Caltech measured the spin rates of three planetary-mass companions - and included the spin rates of two previously studied companions - before comparing them to the spin rates of similarly sized, free-floating brown dwarfs. Their findings, showed that all five companions were spinning at almost exactly the same rate as their brown-dwarf counterparts. "These new spin measurements suggest that if these bodies are massive planets located far away from

their stars, they have properties that are very similar to those of the smallest brown dwarfs," said Heather Knutson, professor of planetary science at Caltech and a co-author of the study.

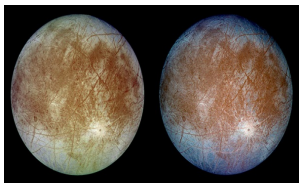


Using the Keck Observatory in Hawaii, Caltech astronomers measured the spin rates for three planetary-mass companions. M. J. Ireland et al.

The researchers put forth two possible explanations for why the planetary-mass companions were spinning at the same rate as their brown-dwarf counterparts. The first is that the companions are, in fact, brown dwarfs. Brown dwarfs form just like regular stars do, out of collapsing clouds of gas and dust. However, unlike stars, brown dwarfs do not have enough mass to kick-start nuclear fusion within their cores, so they never shine with the same blinding intensity as regular stars. The second possibility is that the companions were formed in the same way as regular planets, out of the swirling disks of material that surround young stars. However, if this is the case, then why do the planets have spin rates nearly identical to those of the brown dwarfs? "It's a question of nature versus nurture," said Knutson. "Were the planetary companions born like brown dwarfs, or did they just end up behaving like them with similar spins?"

Although the researchers now have evidence that planetary-mass companions act like brown dwarfs, it is still unclear whether the companions actually are brown dwarfs. Tthe team is currently planning future studies on spin rates to further investigate the subject. "Spin rates of planetary-mass bodies outside our solar system have not been fully explored," said Marta Bryan, graduate student and lead author of the study. "We are just now beginning to use this as a tool for understanding formation histories of planetary-mass objects." By: Jake Parks

Evidence for plate tectonics mounts on Europa 6 December: On Earth, the theory of plate tectonics describes the way large pieces of the planet's crust move and interact. These pieces, or plates, slide over the mantle, the malleable outer layer of Earth's core. Now, new research indicates that the frozen surface of Europa, one of Jupiter's four largest moons, may also experience plate tectonics. If so, this process could be a way to transport materials - such as nutrients for life - to the liquid water ocean just beneath the moon's icy crust.


Europa's surface is criss-crossed with dark streaks and other strange features indicative of a dynamic ice shell. NASA/JPL/DLR

The work, published in the showed via computer models of Europa's ice shell that a process called subduction, in which one tectonic plate meets and slides beneath another, is possible on the moon. The models' results fall in line with prior work showing that regions of Europa's surface appear to be expanding, making them appear much like mid-oceanic ridges on Earth and also suggesting that plate tectonics is at work.

When subduction happens on Earth, it is because the crust is cooler and denser than the mantle. This causes plates to sink, sometimes deep within the mantle. On Earth, the crust and mantle are composed of rock, but on Europa, the moon's shell is made of ice. Though there is evidence that Europa's shell is bi-layered, with the coldest and densest ice on top, any ice plate that began to sink beneath another would warm up, fall in density, and stop, leaving scientists to wonder whether subduction was really possible.

The model used by researcher Brandon Johnson and his class of graduate students at Brown University shows, however, that subduction can still continue if the outermost ice shell incorporates salts, which are denser than ice. Even if a slab warmed up as it sank, reducing its density somewhat, the added density of the salt would allow it to continue sinking. "Adding salt to an ice slab would be like adding little weights to it because salt is denser than ice. So rather than temperature, we show that differences in the salt content of the ice could enable subduction to happen on Europa," Johnson said.

Is that explanation likely? As it turns out, yes. Scientists have observed evidence on the moon's surface of upwelling water from below the ice shell, much like magma wells up from vents on Earth. That upwelling water should leave behind a high concentration of salts. Furthermore, potential cryovolcanism could literally spray the surface with added salts. However the salts reach the surface, one thing is clear - if they allow subduction to happen, then Europa's likelihood as a potential habitat for life just improved. The moon also could become a proxy to allow geologists on Earth to learn more about our own planet. "If we can now study plate tectonics in this very different place, it might be able to help us understand how plate tectonics got started on the Earth," added Johnson.

By: Alison Klesman

Why do meteoroids explode in the atmosphere? 11 December: On 15 February 15 2013, a near-Earth asteroid with a diameter of 20 metres entered Earth's atmosphere traveling at around 60,0000 km/h. Within a few seconds, the cosmic projectile detonated 19 km above the Chelyabinsk region of Russia, releasing as much energy as about 30 Hiroshima atomic bombs. This created a gigantic fireball - known as a superbolide - that caused shock waves to propagate outward for dozens of miles, damaging several thousand buildings and injuring 1,500 people. Though the progenitor of the explosion had an initial mass of over 10,000 metric tons, only about 0.1 percent of that mass is believed to have reached the ground, indicating that something in the upper atmosphere not only caused the rock to explode, but also caused it to disintegrate much more than expected.

Photographer Marat Ahmetvaleev was taking panoramic photos of the winter landscape when he captured this beautiful image of the Chelyabinsk meteoroid as it exploded over Russia in 2013. M. Ahmetvaleev/NASA APOD

A team of researchers proposes a new and previously overlooked mechanism for air penetration in meteoroids, which could help explain the powerful breakup of the Chelyabinsk meteoroid. According to the scientists, as a meteoroid hurtles through Earth's atmosphere, high-pressure air in the front of the object infiltrates cracks and pores in the rock, which generates a great deal of internal pressure. This pressure is so great that it

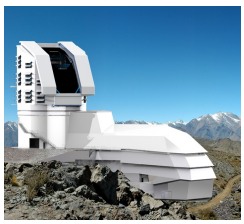
causes the object to effectively blow up from the inside out, even if the material in the meteoroid is strong enough to resist the intense external atmospheric pressures.

"There's a big gradient between high-pressure air in front of the meteor and the vacuum of air behind it," said the study's co-author Jay Melosh, a professor of Earth, Atmospheric, and Planetary Sciences at Purdue University. "If the air can move through the passages in the meteorite, it can easily get inside and blow off pieces."

According to the research paper, "This process of pressure internalization, new to meteoritic studies, would not have been recognized without a two-material fluid dynamics code." This unique computer code allowed researchers to generate models that let both air and solid material coexist in any part of the calculation. "I've been looking for something like this for a while," Melosh said. "Most of the computer codes we use for simulating impacts can tolerate multiple materials in a cell, but they average everything together. Different materials in the cell use their individual identity, which is not appropriate for this kind of calculation."

Though this process of air penetration is a very effective way for our atmosphere to shield us from smaller meteoroids, larger and denser ones will likely not be as affected by it. However, the more we can learn about how different meteoritic materials explode, the more prepared we can be for the next Chelyabinsk. By: Jake Parks

The LSST and big data science 15 December: Construction of the Large Synoptic Survey Telescope (LSST) in Chile is about halfway between first brick and first light. Its 3-ton camera, built with National Science Foundation support, will be the largest digital instrument ever built for ground-based astronomy and will take pictures fast enough to capture the entire southern sky every three nights. According to Andy Connolly, Professor of Astronomy at the University of Washington and Team Lead for LSST Simulations, the Hubble Space Telescope would need 120 years to image an equivalent area of sky.


A depiction of what the completed LSST observatory will look like atop El Peñon summit, Chile. LSST Project/NSF/AURA

Imaging at this rate will generate about 15 terabytes (15 trillion bytes) of raw data per night and 30 petabytes over its 10-year survey life. (A petabyte is approximately the amount of data in 200,000 movie-length DVDs.) Even after processing, that is still a 15 PB (15,000 TB) store. Such huge datasets will give astronomers a ten-year time-lapse 'movie' of the southern sky, yielding new subject matter for time-domain studies and a deeper understanding of the dynamic behaviour of the Universe. It will also change the way science is done - astronomer-and-telescope is giving way to astronomer-and-data as an engine of new knowledge.

The LSST's biggest strength may be its ability to capture transients – rare or changing events usually missed in narrow-field searches and static images. The good news is that software will alert astronomers almost immediately when a transient is detected to enable fast follow-up observations by other instruments. The not-so-good news is that up to 10

million such events are possible each night. With detection rates like these, good data handling is essential.

The LSST program includes Science Collaborations, teams of scientists and technical experts that work to grow the observatory's science agendas. There are currently eight collaborations in such areas as galaxies, dark energy and active galactic nuclei. One of the most unique, however, is the Informatics and Statistics Science Collaboration (ISSC) which, unlike other teams, does not focus on a specific astronomy topic but cuts across them all. New methods will be needed to handle heavy computational loads, to optimize data representations, and to guide astronomers through the discovery process. The ISSC focus is on such new approaches to ensure that astronomers realize the best return from the anticipated flood of new data.

"Data analysis is changing because of the volume of data we're facing," says Kirk Borne, an astrophysicist and data scientist with Booz Allen Hamilton, and a core member of the ISSC. "Traditional data analysis is more about fitting a physical model to observed data. When I was growing up, we didn't have sample sizes like this. We were trying to understand a particular phenomenon with our small sample sets. Now, it's more unsupervised. Instead of asking 'tell me about my model,' you ask 'tell me what you know.' Data become the model, which means that more is different."

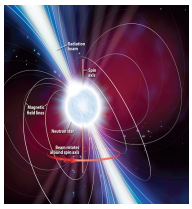
LSST data will almost certainly expand the chances for surprise. "When we start adding different measurement domains like gravitational wave physics and neutrino astrophysics for exploration," adds Borne, "we start seeing these interesting new associations. Ultraluminous infrared galaxies are connected with colliding starbursting galaxies, for example, but it was a discovery made by combining optical radiation with infrared. Quasars were discovered when people compared bright radio observations of galaxies with optical images of galaxies."

The LSST Data Management Team is starting to orient the astronomy community to what is coming with a series of conferences and workshops. The next generation of big data astronomers is also being groomed through graduate curricula and a special fellowship program. Students need to understand early on what it's like to do large-scale experiments, to design equipment and software, and to collaborate with very large teams. Astronomy today is entering the age of big data just like particle physics did 20 or 30 years ago. Telescope data are being packaged for a wide audience, too. The LSST Education and Public Outreach (EPO) program is working to involve classrooms, citizen scientists and the general public as deeply in big data astronomy as they want (or dare) to go. Primary EPO goals are to help educators integrate real LSST data into classrooms and introductory astronomy courses, and to help non-specialists access LSST data in ways similar to those of professional astronomers. Working through platforms like Zooniverse, almost anyone will be able to conduct serious research projects. "Citizen volunteers should be thought of as members of the science collaboration," says Amanda Bauer, Head of LSST EPO. By: Steve Murray

Atmospheres are key to pulsar-proofing exoplanets 20 December: Pulsars are some of the strangest and least understood objects in the universe. These city-sized stellar cores are not only as dense as a backpack stuffed with Mount Everest, but also can spin as fast as a top. Furthermore, thanks to their insanely powerful magnetic fields,

pulsars energetically funnel particles to their poles, which emit extremely intense, narrow beams of high-energy light.

These bursts of deadly radiation (plus surges of other damaging particles) make the idea of living around a pulsar seem laughable. However, for the first time, astronomers have determined what it would take for a habitable exoplanet to survive the harsh conditions of a pulsar system. And as it turns out, it only takes an atmosphere - albeit a very (very) thick one. In a study, researchers calculated that the habitable zone - the region around a star where liquid water can exist - for an exoplanet around a pulsar could be as large as the orbit of Earth around the Sun. However, they stressed that this requires the pulsar's planet be a super-Earth, capable of sustaining an atmosphere up to a million times as thick as our own.


In a recently published study, astronomers investigated the habitability zone around a pulsar for the first time. Roen Kelly (Astronomy magazine)

The first confirmed detection of any exoplanet came way back in 1992 with the discovery of multiple terrestrial-mass planets orbiting the pulsar PSR B1257+12, located 2,300 light-years away in the constellation Virgo. Three rocky exoplanets are now known to orbit this pulsar, and two of them are super-Earths (each weighing roughly four times the mass of Earth). Could any of these exoplanets really be habitable?

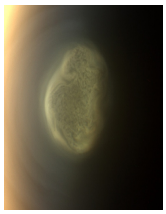
Since a pulsar is actually a type of neutron star - a collapsed core of a massive dead' star - it no longer produces heat through internal thermonuclear reactions. Because of this lack of a steady energy source, researchers needed to find another way that PSR B1257+12 could warm up its planets to water-friendly temperatures. Using archival X-ray observations taken with the Chandra X-ray Observatory, astronomers Alessandro Patruno (Leiden University and ASTRON) and Mihkel Kama (Leiden University and Cambridge University) investigated the pulsar to determine how much energy it was releasing in X-ray light. Based on the Chandra data, the researchers calculated that the two super-Earth planets around the pulsar were receiving enough energy from X-rays to sustain liquid water. That is, as long as they have absurdly dense atmospheres.

According to the study, if a planet around PSR B1257+12 has a thick enough atmosphere, it can absorb and convert the pulsar's deadly X-rays and high-energy particles into relatively harmless infrared radiation - otherwise known as heat. However, the atmosphere would need to be so thick that the conditions on the exoplanet's surface would be similar to those found at the bottom of the Mariana Trench, the deepest part of Earth's oceans.

"According to our calculations, the temperature of the planets might be suitable for the presence of liquid water on their surface," co-author Alessandro Patruno said. "Though, we don't know yet if the two super-Earths have the right, extremely dense atmosphere." Considering the Milky Way alone is estimated to contain around 200,000 pulsars, understanding how planets both behave and form around these objects is not a trivial endeavour. In future studies, astronomers would like to use the European Southern

Observatory's ALMA telescope to investigate dust discs around other pulsars, hopefully shedding light on the early evolution of pulsar-orbiting exoplanets. By: Jake Parks

Titan's too-cold poles explained 21 December: The Cassini spacecraft spent more than a decade charting the Saturn system; its mission included observing Saturn's largest moon, Titan. Cassini watched the behaviour of the moon's atmosphere for nearly half the moon's year (which, like Saturn's, lasts nearly 30 Earth years). On most worlds with atmospheres, including Earth, Mars, and Venus, 'hotspot' develop at high altitudes above the poles during the winter as sinking air becomes compressed and heats up. While such a hotspot did develop on Titan in 2009 as winter began, temperatures in the south polar atmosphere later plummeted in 2012, falling as low as–153 degrees Celsius through late 2015. Only in 2016 did the area begin to warm up again.


Cassini spotted this swirling vortex of cool gas at Titan's southern pole June 27, 2012, as the atmosphere in the moon's southern hemisphere cooled with the oncoming winter, which was not expected. NSA/JPL-Caltech/Space Science Institute

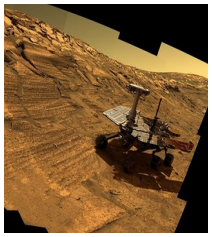
A paper published in *Nature Communications* has an explanation: 'Exotic' chemical reactions between Titan's atmosphere and incoming sunlight produce byproducts such as ethane, acetylene, hydrogen cyanide, and cyanoacetylene, which cool the atmosphere. Though they are created at high altitudes, subsequent atmospheric circulation can dramatically change the abundance of these gases in the moon's atmosphere. When cool air began sinking as winter set in on the moon's southern pole, it carried these gases deeper and led to greater cooling.

"This effect is so far unique in the solar system and is only possible because of Titan's exotic atmospheric chemistry," said lead author Nick Teanby of the University of Bristol's School of Earth Sciences. Though unique in our solar system, this atmospheric behaviour might be more widespread elsewhere. "A similar effect could also be occurring in many exoplanet atmospheres having implications for cloud formation and atmospheric dynamics," he added. Planetary scientists may get a closer look at Titan in the not-so-distant future. NASA has just approved funding for the further development of the Dragonfly mission, a combination quadcopter and lander destined for Titan. While (if selected) Dragonfly's main goal would be to explore Titan's chemistry and habitability, its data could include details about its atmospheric behaviour as well. By: Alison Klesman

How rovers weather the winter on Mars 26 December: The shortest, coldest days of winter are approaching for those who live in Earth's Northern Hemisphere. However, on Mars, the Opportunity rover is already in the midst of the Red Planet's doubly-long winter in its southern hemisphere, with the period of least sunlight having passed in October and November. During winters on Mars, the rover must rely on a smart strategy that employs tilting its solar panels northward to maximize energy for its ongoing mission.

Mars, like Earth, is tilted on its rotation axis with respect to its orbit around the Sun. Its tilt is about 25 degrees, while Earth is tilted about 23.5 degrees, so the two planets experience similar seasons - but Mars, with its 1.88-Earth-year-long year, has seasons that

last almost twice as long. That makes planning for power acquisition (via solar panels) and usage (through driving and data collecting) essential during the winter season, when sunlight is scarce and the Sun takes a northern path through the sky from the rover's point of view. To gain power for mission-necessary tasks, the rover must tilt itself northward to catch as much sunlight as possible during the long winter season. Opportunity is currently exploring a valley known as 'Perseverance Valley' on the western rim of Endurance Crater. It has been there for about five months, and the location puts it in an ideal spot to catch the northern Sun. As it stops to collect valuable photons at planned sites nicknamed 'lily pads', the rover takes the time to explore the immediate area, studying rocks along the crater's rim and imaging the valley in great detail.


A simulated view of NASA's Opportunity Mars Exploration Rover in Endurance Crater, near where it will be spending this winter. NASA/JPL-Caltech/Cornell

The energy available to a solar-based Mars rover depends on more than just the position of the Sun and the length of the Martian day. It also depends on the condition of the solar panels, which can be easily covered in dust kicked up by everyday winds and during storms. Sometimes those winds pile dust onto the panels, limiting their ability to absorb sunlight. Other times, the winds clean the panels, revealing a smooth surface to boost the rover's power-collecting capabilities. Currently, Opportunity's panels are relatively clean, but there is a potential dust storm season approaching next year, so mission planners are remaining optimistic but watchful. "If Opportunity's solar arrays keep getting cleaned as they have recently, she'll be in a good position to survive a major dust storm. It's been more than 10 Earth years since the last one and we need to be vigilant," said Jennifer Herman, who leads Opportunity's power subsystem operations team at NASA's Jet Propulsion Laboratory.

January will mark the 14th (Earth-year) anniversary of the Opportunity and Spirit rovers, which were designed to last about three months. Instead, Opportunity is still going strong, though Spirit became stuck in a sand trap and was unable to tilt northward during its fourth winter in 2009. Spirit's mission was ultimately ended in May 2011, but Opportunity persists - as does the Curiosity rover, which does not rely on solar power, but instead has a radioisotope thermoelectric generator to provide power. For now, Opportunity will continue 'leaping' from lily pad to lily pad, exploring the valley for clues as to how it was formed, and whether water (and how much) was involved. Its ultimate goal is the bottom of the valley, but that is an area with no lily pads available for soaking up wintertime sunlight — so it will have to wait for the seasons to change. By: Alison Klesman

Arecibo's restored radar captures new images of asteroid 3200 Phaethon 27 December: Following months of hindered radar observations caused by Hurricane Maria's power outages, the Arecibo Observatory Planetary Radar was recently brought back online just in time to observe asteroid 3200 Phaethon (source of the annual December Geminids meteor shower) as it neared Earth. On 16 December, at its closest, the asteroid was 10.3 million kilometres away, the nearest it will be until 2093. The radar images taken during its fly-by have allowed astronomers to distinguish new characteristics of the asteroid.

The images, captured at a resolution 75 metres per pixel, reveal the asteroid is spheroidal in shape and has a larger body than previously thought. Researchers originally believed that the object had a diameter of about 4.8 km, but the new snapshots show it has a diameter of roughly 6 km. The researchers also used Arecibo's radar to spot a depression near 3200 Phaethon's equator that stretches a few hundred meters at minimum, as well as a dark, spherical spot close to one of the asteroid's poles.

"These new observations of Phaethon show it may be similar in shape to asteroid Bennu, the target of NASA's OSIRIS-REx spacecraft, but more than 1,000 Bennus could fit inside of Phaethon," said Patrick Taylor, Universities Space Research Association scientist and group leader for Planetary Radar at Arecibo. "The dark feature could be a crater or some other topographic depression that did not reflect the radar beam back to Earth."

Because of its large size and close proximity to Earth, Phaethon is categorised as a 'potentially hazardous' asteroid, being the second largest object with that designation. NASA's Planetary Defence Coordination Office relies on radar technology to observe, classify, identify specific features, and accurately establish orbital paths for these asteroids. "Arecibo is an important global asset, crucial for planetary defence work because of its unique capabilities," said deputy director of Arecibo Observatory and USRA's Joan Schmelz. "We have been working diligently to get it back up and running since Hurricane Maria devastated Puerto Rico." Though Arecibo's structure was only minimally damaged when the hurricane hit, a long-term lack of power and diesel fuel for its generators has drastically hampered its radar operations. The observatory was able to re-establish radio astronomy observations within a few days of the storm, but radar technology was not up and running until commercial power was restored in early December. By: Amber Jorgenson

Astronomers may need to rethink the way black holes form jets 29 December: Black holes are known for their extreme behaviour - in particular, the high-speed jets of matter they launch into space. These jets have long fascinated astronomers, who believe they are associated with the black hole's magnetic field. However, new measurements of the magnetic field around a black hole have found that it is surprisingly weak - which means astronomers may need to rethink the mechanism behind the jets.

The measurements were taken by a team of astronomers from the University of Florida (UF) with the Canarias InfraRed Camera Experiment (CIRCE) on the Gran Telescopio Canarias (GTC), a 10.4-metre telescope in the Canary Islands and the current record-holder as the world's largest single-aperture telescope. Using CIRCE, an infrared camera built for the massive GTC, they observed jet activity from V404 Cygni, a nine-solar-mass black hole about 8,000 light-years away, during a burst in jet activity in 2015 that lasted just a few weeks. Their results are the first precision measurements of a black hole's magnetic field ever taken - and they show that V404 Cygni has a magnetic field about 400 times weaker than expected.

That challenges theories currently used to explain the jets as a result of interactions between the black hole's magnetic field and matter in its accretion disk - the swirling disk of gas and dust created as matter is trapped by the black hole's gravity and falls inward. This disk lies outside the event horizon, rendering it visible to astronomers and allowing them to spot the black hole via its light. "Our surprisingly low measurements will force

new constraints on theoretical models that previously focused on strong magnetic fields accelerating and directing the jet flows," said UF professor Stephen Eikenberry. "We weren't expecting this, so it changes much of what we thought we knew." However, this challenge is a welcome one, as it will finally help astronomers begin to unravel the poorly understood magnetic fields around these exotic objects, even if they turn out too weak to launch jets and other activity. "This discovery puts us one step closer to understanding how the universe works," added lead author Yigit Dalilar. By: Alison Klesman

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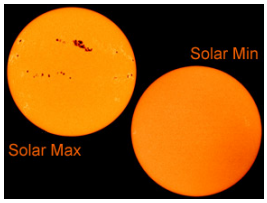
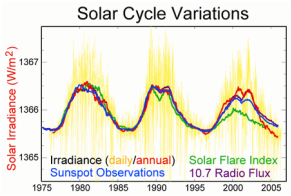
DID YOU KNOW?

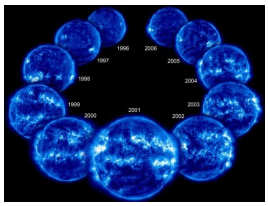
The Sun Part 22: **Solar cycle 1**



Sunspot cycle



11 year solar cycle


Solar cycle in ultraviolet

This is also known as the sunspot cycle or the solar magnetic activity cycle. The best known of the Sun's cycles, the name applies to the nearly periodic 11-year observable change in the Sun's activity. Changes include altered levels of solar radiation and ejection of solar material, including solar flares, coronal mass ejections (CME), and changes in the Sun's appearance, including changes in sunspot numbers and position. Changes also occur on Earth eg numbers and strength of aurorae.

Solar maximum and solar minimum, the two extremes of the cycle, refer to the periods of maximum and minimum sunspot count. One cycle spans from one solar minimum to the next one. During solar minimum, solar activity like sunspots and solar flares often does not occur for days at a time. The dates of the solar minimum and maximum are identified by a smoothed average over 12 months of sunspot activity, so identifying the date can usually only happen six months after the event has taken place. At solar maximum, the Sun's magnetic field lines are the most distorted, this phenomenon being associated with the highest levels of solar activity, both in terms of numbers and amplitude of events like solar flares and CMEs.

In each successive cycle, the north and south magnetic polarities of the Sun are reversed, so there is, effectively, a 22-year cycle. However, nearly all manifestations of the solar cycle are insensitive to polarity, so the 11-year cycle remains the focus of interest. The 11-year periodicity is thought to arise from the nature of the solar dynamo.

Observational history From 1826 onwards, the German amateur astronomer Samuel Schwabe started keeping daily records of sunspot numbers in his efforts to find a planet closer to the Sun than Mercury. In 1843, he announced that these numbers varied with a period of about 10 years. In 1857, Rudolph Wolf, a Swiss astronomer, studied these and other observations going back as far as those of Galileo. He confirmed Schwabe's findings and, although refining the cycle length to an average of 11 years, formally acknowledged Schwabe as the discoverer of the sunspot cycle.

In 1899, the American astronomer George Ellery Hale invented the spectroheliograph which he used to study the Sun's surface features and prominences and advanced understanding of sunspots. He identified that they are cooler than the surrounding photosphere (1905) and was also the first to link the solar magnetic field and sunspots (1908). His observations enabled him to describe the physical basis of the solar cycle. In 1919, he showed that the magnetic polarity of sunspot pairs is constant throughout a cycle, is opposite across the equator throughout a cycle, and reverses itself from one cycle to the next. This led to his 1925 proposal that the full solar cycle lasts 22 years, covering two periods of increased and decreased sunspot numbers, accompanied by polar reversals of the solar magnetic field dipole, before the system returns to its original state.

Solar cycle history Sunspot numbers over past 11,400 years have been reconstructed using carbon-14 dendrochronology in addition to more recent visual observation records. Since observations began, the length of solar cycles have ranged from 9-14 years and significant intensity amplitude variations have also occurred. Cycles with larger maximum amplitudes tend to take less time to reach maximum than cycles with smaller amplitudes (the Waldmeier effect). Maximum amplitudes have also been found to be negatively correlated to the lengths of earlier cycles, aiding prediction.

The level of solar activity since the 1940s has been exceptional. The last period of similar magnitude was around 9,000 years ago during warm Boreal period. Overall, the Sun was at a similarly high levels of magnetic activity for only around 10% of the past 11,400 years. Also, almost all early high-activity periods were shorter than the present one.

Solar cycles are numbered, cycle 1 beginning in August 1755. The current cycle number is 24. It began in January 2008, with minimal activity until early 2010. Since then, it has featured a double peak solar maximum, 99 in 2011 and 101 in early 2014. Despite these peaks, it is currently on track to have lowest recorded sunspot activity since accurate records began in 1750. Cycle 23 lasted 11.6 years, from May 1996 to Jan 2008. The maximum smoothed sunspot number (averaged over a 12 month period) was 120.8 and the minimum 1.7. 805 days had no sunspot activity.

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

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