"The Southern Cross"

HERMANUS ASTRONOMY CENTRE NEWSLETTER

MARCH 2017

This month's Centre meeting
This will take place on **Monday 20 March** at the **Scout Hall** starting at **19.00**. Centre chairperson Dr Pierre de Villiers will be talking on 'What science we have learned from space telescopes'.

Important notice 2015 membership renewal window closed
If you have not already renewed your membership, from this month, your details will be removed from the Centre's membership list. The implications of this are that you will no longer receive the monthly sky maps or Southern Cross newsletter, no longer be eligible to join Centre trips, and, if you wish to attend monthly or interest group meetings, on each occasion, you will have to pay the R20 visitor's fee. All is not lost, however. You are welcome to rejoin the Centre at any time by contacting Laura Norris, the Treasurer, at meetings, on 028 3164453 or at dunorris@whalemail.co.za

WHAT'S UP?

Two star clusters with similar names At this time of year, it is possible to see two open clusters named 'Pleiades'. The original (northern) Pleiades (M45), in Taurus (the bull) can be found low to the north west of Orion (the hunter). It is known for the 'Seven Sisters', the brightest of the stars in the rich cluster, which are visible to the naked eye. The cluster was named after the Greek mythological character Pleione and the daughters she had with Atlas. Located about 400 ly away, the cluster contains about 100 stars in total, many of which are visible through binoculars. In contrast, the 'Southern Pleiades' (IC 2602) is located high in the sky to the south. Named for its resemblance to the 'proper' Pleiades, this cluster is located at the northern end of the diamond cross, a shape formed by four of the stars in the Carina constellation (the keel of the mythical ship of the Argonauts). The diamond cross can be found between the Southern Cross and the False Cross (found near Canopus). Discovered in 1751 at the Cape by Nicolas de Lacaille, the Southern Pleiades is around 480 ly away. Of its 60 or so stars, several are visible to the naked eye, the brightest being Theta Carinae. With binoculars, it is possible to identify the distinctive M-shaped asterism within the cluster.

LAST MONTH'S ACTIVITIES

Monthly centre meeting The annual general meeting took place on 20 February. Chairperson Pierre de Villiers gave a comprehensive summary of the wide range of activities which took place during the Centre's ninth year. The main events were continuing progress towards obtaining permission to construct the Astronomy Education Centre and Amphitheatre, and the installation and opening of the scale model of the solar system along the Cliff Path. Two meetings, co-hosted with SANSA, were held in addition to the usual monthly meetings. These were, as usual, presented by both professional and amateur speakers and covered a wide range of interesting topics. Activity with the two youth groups continued, mainly at Hawston, with both groups being involved in painting the planets for the solar system model. Adverse weather conditions caused cancellation of some planned observing events, like the partial solar eclipse in September. However, the following events were successful: observation of the transit of Mercury, two public stargazing events, and two stargazing, one moonwatching and a susnspot observation events with the youth groups.

Pierre then gave an overview the range of regular activities which took place during 2016, as well as the electronic resources available to members. Finally, he thanked all those who have contributed to the ongoing success of the Centre, and confirmed the make-up of the committee in 2016.

Centre member, John Saunders then gave a short summary on the youth astronomy presentation he gave to primary school learners in the UK. Based on the presentation developed in Hermanus, he focussed on the Sun, Earth (including satellites and space debris), the Moon, the solar system, major constellations and celestial objects eg nebulae, clusters, the Milky Way and, finally, using the Hubble Ultra deep field image to illustrate the vastness of the Universe.

Interest groups

Cosmology 25 people (22 members, 3 visitors) attended the meeting on 6 February. They viewed the first two pf a DVD series ‛ Particle Physics for Non-Physicists: a Tour of the Microcosmos' presented by Prof Steven Pollock from the University of Denver at Boulder. The lectures were L3: 'The pre-history of particle physics' and L4: 'The birth of modern physics'.

Astro-photography At the meeting on 13 February, members continued to discuss processing of their own astro-images.

Other activities

Joint U3A/HAC presentations The first two of four presentations at U3A, jointly co-hosted by HAC, took place this month. On 21 February, Centre member Johan Retief talked on 'Mars, the red planet – Can mankind go there?' and, on 28 February, Prof Patrick Woudt from UCT talked on 'Recent developments in astronomy: southern horizons in time-domain astronomy'

Eclipse observation On 26 February, approximately 50 people, including Centre members and members of the public attended the event held at Gearing's Point to observe the partial solar eclipse which took place during the late afternoon. Strong winds and veld fire smoke did not dull the interest of those who observed the event through filters or indirect methods using the naked eye, binoculars and two telescopes of differing size.

Educational outreach

Hawston Secondary School Astronomy Group Weekly meetings continued during February.

Lukhanyo Youth Club No meetings took place in February.

THIS MONTH'S ACTIVITIES

Monthly centre meeting This month's meeting will take place on **Monday 20 March** at the **Scout Hall** starting at **19.00**. Centre chairperson Dr Pierre de Villiers will be talking on 'What science we have learned from space telescopes'. Pierre has given several presentations on a range of topics over the years, all very informative and visually interesting, and this one is sure to maintain the same high quality.

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. This month's meeting will take place on **6 March** at the Scout Hall. Attendees will watch the next two episodes in the DVD series 'Particle Physics for Non-Physicists: a Tour of the Microcosmos'. The series will continue throughout 2017.

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 third Monday of each month. The next meeting is on **13 March**. Members will continue work on processing their own astro-images.

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 continue to work towards accessing a telescope or images which learners can start using this year.

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

FUTURE ACTIVITIES

Possible trips for 2017 are being considered. Details will be circulated to members when arrangements have been made.

2017 MONTHLY MEETINGS

Unless stated otherwise, meetings take place on the **third Monday** of each month at the Scout Hall beginning at 19.00.

20 Mar	'What science we have learned from space telescopes' Presenter: Pierre de Villiers, Committee chairperson
17 April	'Physics in the dark: the missing matter and energy in the Universe'. Presenter: Kate Storey-Fisher, UWC
15 May	'Asteroids, comets and dwarf planets' Presenter: Johan Retief, Centre member
19 June	'The monsters of deep space' Presenter David Groenewald, SAAO, CT
17 July	'Deep sky stargazing' Presenter: Auke Slotegraaf, psychohisotiran and editor of the Sky Guide

21 Aug	Topic to be confirmed. Presenter: Dr Amanda Sickafoose, SAAO, CT
18 Sept	TBA
16 Oct	'Jupiter: the neighbourhood bully' Presenter: Jenny Morris, Committee member
20 Nov	TBA
11 Dec	Xmas party

ASTRONOMY EDUCATION CENTRE AND AMPHITHEATRE (AECA)

A decision on the planning application by the Council of Overstrand Municipality continues to be awaited. Hopefully, this will take place at their meeting this month. 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.

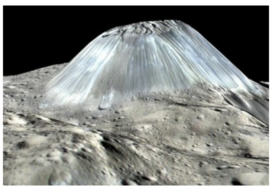
We would, therefore, be very grateful if members could either continue to contribute to the campaign or start becoming a contributor. Both single donations and small, regular monthly donations, of any amount, are welcome. Contributions can take the form of cash (paid at meetings), or online transfer,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

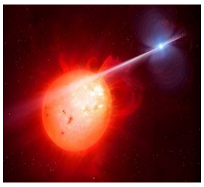
The case of Ceres' disappearing volcanoes 2 February: In 2015, NASA's Dawn spacecraft discovered a lone 4 km high mountain on the dwarf planet Ceres. Identified as a cryovolcano, which erupts ice and other volatiles instead of lava like a traditional volcano, Ahuna Mons was magnificent, but alone on Ceres' surface. Now, however, scientists say that Ceres may have been home to many more such cryovolcanoes in the past, which could have slowly disappeared and left Ahuna Mons as the only remaining feature of recent geologic activity.


This image, created from combined Dawn images, shows a slightly exaggerated view of Ceres' lone cryovolcano, Ahuna Mons. NASA/JPL-Caltech/UCLA/MPS/DLR/IDA

Michael Sori of the Lunar and Planetary Laboratory at the University of Arizona in Tucson explains why Ahuna Mons is such a mystery, saying, "Imagine if there was just one volcano on all of Earth. That would be puzzling." However, Sori's team has now proposed a possible solution to this exact puzzle, a process called viscous relaxation. If this process is truly at work on Ceres, then, "We think we have a very good case that there have been lots of cryovolcanoes on Ceres but they have deformed," Sori says.

Viscous relaxation refers to the flow of solids over time. On Earth, the best example of this process is the flow of glaciers, which are solid ice but move and flow slowly, given enough time. While viscous relaxation does not apply to Earth's volcanoes, which are made of rock, it could apply to cryovolcanoes, which are made of ice, just like glaciers. Sori's team speculates that older cryovolcanoes have undergone such viscous relaxation over the past few millions or billions of years, possibly aided by Ceres' close orbit to the sun. This would leave only the younger Ahuna Mons clearly visible on Ceres' surface. Based on computer models of this process, and assuming that Ahuna Mons is composed of at least 40 percent water, Sori's team estimates that this feature would flatten out at a rate of 10-50 metres every million years. Because Ahuna Mons is only 200 million years old at most, "it just hasn't had time to deform," Sori explains. By: Alison Klesman

Astronomers discover a white dwarf that acts like a pulsar 7 February: Since their discovery by Jocelyn Bell and Antony Hewish in 1967, pulsars have intrigued astronomers as unique and exotic objects. A pulsar is a type of neutron star that emits focused beams of radiation from its poles as it spins. Now, astronomers have discovered a pulsar that's not a neutron star at all, but a white dwarf. It is the first white dwarf pulsar ever discovered, after more than 50 years of searching the skies for such an object.


Artist's impression of AR Scorpii system. . M. Garlick/University of Warwick/ESO

The discovery was made by Professors Tom Marsh and Boris Gänsicke at the University of Warwick's Astrophysics Group, and Dr. David Buckley of the South African Astronomical Observatory. They found that the binary system AR Scorpii (AR Sco), which sits 380 light-years away in the constellation of Scorpius, contains a white dwarf acting as a pulsar. Shortly after the first pulsar's discovery, astronomers sought to understand the type of star responsible for such a signal. The pulsar that Bell and Hewish discovered had a period of slightly over one second (1.3373011 seconds). Based on stellar models, this fell just within the rotational limits of a white dwarf. However, much faster pulsars were soon discovered, with periods of milliseconds. Only neutron stars were capable of rotating so quickly, so astronomers settled on these stellar remnants as the common mechanism behind pulsars.

The AR Sco system comprises a white dwarf and a red dwarf star, which orbit each other every 3.6 hours at a distance of about 1.4 million kilometres, or three times the distance between Earth and the Moon. As the white dwarf rotates around its axis every two minutes, it blasts its companion with a beam of radiation that excites electrons in the red dwarf's atmosphere, accelerating these particles to nearly the speed of light. This causes brightness changes that can be observed from Earth at exactly the period of the white dwarf's rotation.

"AR Sco is like a gigantic dynamo: a magnet, size of the Earth, with a field that is ~10,000 stronger than any field we can produce in a laboratory, and it is rotating every two minutes. This generates an enormous electric current in the companion star, which then produces the variations in the light we detect," said Professor Boris Gänsicke.

Neutron stars, which comprise the entire set of pulsars that had been discovered to date, are the dense remnants of a massive stars core left over after it ends its life in a supernova explosion. It takes a star several times the mass of the Sun to leave such a remnant behind. White dwarfs have a much less violent past - they are the smaller, slightly less dense cores of stars like the Sun, left over once the stars outer layers have been blown away like a bubble as a planetary nebula. Most white dwarfs are roughly the size of Earth, while most neutron stars are only the size of, say, New York City. Red dwarf stars, thought to be the most common and longest-lived stars, are cool, low-mass Main Sequence stars (in the hydrogen-burning stages of their life) that only contain about 7.5 to 50 percent of the mass of our Sun.

The white dwarf pulsar in AR Sco might be Earth-sized, but it is 200,000 times as massive as our planet. It also has an electromagnetic field 100 million times the strength of Earth's, which is responsible for the beams of radiation it emits as a pulsar. "The new data show that AR Sco's light is highly polarised, showing that the magnetic field controls the emission of the entire system, and a dead ringer for similar behaviour seen from the more traditional neutron star pulsars," said Professor Tom Marsh.

This discovery, and others like it, point to the possibility that white dwarfs are not simply the inert remnants of Sun-like stars destined to simply fade away, but continue to play an active role long after the stars hydrogen-burning phase is complete.   By: Alison Klesman

Astronomers find a new class of black holes 8 February: Some black holes are small. Some black holes are giant. Oddly enough, in the cosmic fight between innocent passing stars and voracious black holes, scientists have never found a mid-sized black hole. Until now.

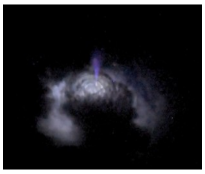

Globular cluster Tuc 47 based on data from FORS1   ESO

The star cluster 47 Tucanae, located about 13,000 to 16,000 light years from Earth, is a dense ball of stars. Hundreds of thousands of stars compacted into a 120 light-year span give off gamma rays and X-rays and more energetic events, but to date, no black holes had been found there. The centre seemed ripe for opportunities to find one, but a lack of tidal disruption events and a jumble of stars hard to sift through obscured finding any lurking black holes there. The Harvard-Smithsonian Centre for Astrophysics turned to two tactics to find the black hole instead. First, they observed the motion of the stars in aggregate, and compared the rotation rate to what would happen if a black hole was present. Secondly, they observed the position of pulsars in the globular cluster.

Black holes are the densest objects in the universe. However, neutron stars (which include pulsars) are a close second, as both can result from similar events in which a giant star goes supernova and its dense stellar core collapses (though a few other mechanisms can create black holes.) If the pulsars were the biggest objects in the globular cluster, they would be nearer to the core and act as a chief gravitational attractor. Instead, pulsars are scattered across the cluster rather than congregating in the centre of the cluster. This all suggests that a black hole of 2,200 solar masses is lying at the centre of 47 Tucanae. Until now, though, astronomers have typically only found black holes of below 100 solar masses or above 10,000, the latter of which are the behemoths that power galaxies. These intermediate-mass black holes are believed to be seeds of supermassive black holes. As black holes feast, they gain mass.

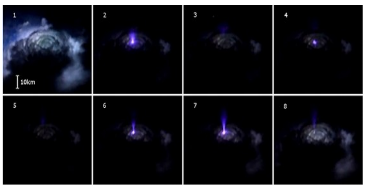
The intermediate-mass black holes may form from several stars in a dense cluster collapsing, with the resulting black holes merging and creating a bigger black hole. They could also be black holes that have accumulated mass over time – and, indeed, 47 Tucanae is 12 billion years old, giving plenty of time to slurp up matter. There is also a scenario under which, shortly after the Big Bang, certain areas of the expanding universe were so dense they formed black holes shortly after the event. By: John Wenz

Elusive blue lightning filmed dancing above a thunderstorm 9 February: In Earth's upper atmosphere, blue jets, red sprites, pixies, halos, trolls and elves streak toward space, rarely caught in the act by human eyes. This mixed-bag of quasi-mythological terms are all names for transient luminous events, or, quite simply, forms of lightning that dance atop thunderstorm clouds. Airplane pilots have reported seeing them, but their elusive nature makes them hard to study. However, ESA astronaut Andreas Morgensen, while aboard the International Space Station in September 2015, filmed hundreds of blue jets flashing over a thunderstorm that was pounding the Bay of Bengal, confirming a mysterious atmospheric phenomenon.

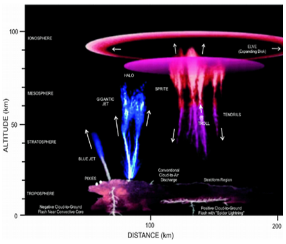

A blue jet caught on camera over the Bay of Bengal ESA

According to Morgensen and researchers at the Denmark National Space Institute, these observations are the first of their kind, and offer a rare glimpse of poorly understood atmospheric phenomena. His work also proves that the ISS is a perfect lab for studying elves and pixies, and a planned follow-up mission should reveal even more.

Storm clouds are like electrical cakes with alternating layers of negatively and positively charged ions. Air currents tear through the sky cake, squashing the layers and reversing their stacking order. When the base layer's charge differs from the earth's charge - zap. The seems to be true for layers higher in the atmosphere, but instead of striking Earth, transient luminous events discharge into space. Of course, you need to be above the clouds to see them; thus, the reason they are difficult to study.


A frame-by-frame of the storm cloud that produced the pulsating blue jet DOI: 10.1002/2016GL071311

The first glimpse of a red sprite was captured in 1989, and it spurred researchers to look above the thunderclouds to see what else was happening higher up. Scientists have since used satellites to study space lightning, but their viewing angle is not ideal for gathering data on sprites and jets. However, at its lower orbit, the ISS is perfectly positioned to record such events, and that was precisely the aim of the Thor experiment, which was conducted by Morgensen, the first Danish astronaut aboard the ISS. He used a Nikon D4 camera tuned to the appropriate settings, and peered out of the window of the Russian Pirs module when forecasts favoured a storm.



The various types of transient luminous events. D D Sentman, U Alaska

On 8 September, he filmed a doozy near India, and recorded 245 blue flashes above the clouds in a 160-second video. The flashes were about 1 km wide, and 18 km in altitude. It is not clear what causes these blue flashes and scientists, in fact, are not sure how familiar cloud-to-ground lightning forms, either. These electrical charges from thunderstorms may alter chemistry in the upper atmosphere, which could have implications for Earth's radiation balance. For example, the interaction between nitrogen and electricity is though to give red sprites their colour.

Scientists need to know much more about these events to formulate any firm conclusions, and they will get some help. Later this year, the Atmosphere-Space Interactions Monitor (ASIM) will head to the ISS to continuously monitor thunderstorms - combing the atmosphere for transient luminous events. The ASIM experiment will observe these events in two ultraviolet optical bands, as well as the X- and gamma-rays. By: Carl Engelking

Astronomers catch a supernova just as its big boom begins 13 February: When massive stars (on the order of ten or more times the mass of our Sun) end their lives, they go out with a bang. In an instant, these stars send out a massive shock wave as type II supernovae, spreading the contents of their interiors - hydrogen, helium, and heavier elements that include silicon, oxygen, and iron - into the interstellar medium, sprinkling the materials of future stars and solar systems throughout the galaxy.

Supernovae have been observed, both within our galaxy and in other galaxies, for thousands of years, and their results can be seen as nebulae, neutron stars, and black holes. However, what is it that actually makes these stars go bang? The answer is: We do not know. Ofer Yaron of the Weizmann Institute of Science in Israel and his colleagues have just brought us a little closer to finding that answer. Yaron and his colleagues report their measurements of supernova SN2013fs, which exploded in the nearly galaxy NGC 7610 in 2013. Their results represent some of the earliest post-explosion follow-up observations of a supernova event, including the earliest spectra of a supernova ever, shedding light on the dying star's final days.


SNR E0519-69.0, in the Large Magellanic Cloud. NASA/CXC/Rutgers

What we do know is that the evolution of a star prior to its explosion likely holds key clues about the processes that precede type II supernova. The stars behaviour, such as its growth into a red supergiant and the mass loss it experiences during this phase, affect the results we see when the star does explode. However, the red supergiant phase is actually quite short (cosmically speaking; this phase can last between a few hundred thousand to maybe a million years), so we rarely see stars in this part of their life cycle. Because supernovae are instantaneous and unpredictable, we also rarely catch them right as they're happening. The chance to see a supernova just as it is occurring, rather than days or weeks later, could translate into the data needed to trace back the stars evolution and even understand the instant of the explosion itself.

One of the processes astronomers are looking to trace is the red giant's history of mass loss. Mass can be lost through expansion as the star ages, as well as via eruptions of the stars upper atmosphere. This mass loss can cause a "shell" of circumstellar material that blankets the star. And when the supernova occurs, the way it lights up this material can thus tell astronomers about how the material was lost, highlighting the stars most recent history like the last few rings in a tree's trunk.

When the supernova occurs, the shock wave it produces causes a process called photoionisation, which strips electrons away from the gas surrounding the star. Shortly thereafter, all these free electrons recombine with the gas atoms of the shell (in a process aptly called recombination), which causes the gas to shine. Studying the resulting spectrum of the gas reveals information about the elements in this gas shell, as well as its density, motions, and the distance of the gas from the star. As the shock wave moves through the shell surrounding the star, it lights up different features, all of which provide 3-dimensional information about the structure of the cloud. All of this information can be used to reconstruct a picture of the environment around the star just before the supernova occurred. The key, though, is catching the supernova in its earliest stages, because as the shock wave progresses through the material around the dying star, it quickly distorts it and blows it away, erasing the information there like shaking a cosmic Etch A Sketch.

SN2013fs was first detected in October 2013 by the intermediate Palomar Transient Factory (iPTF) survey. The event was quickly followed up in multiple wavelengths, including X-ray, ultraviolet, optical, and infrared. These follow-up observations include the earliest spectroscopy of a type II supernova ever obtained. The explosion was first identified just three hours after it occurred, and the first spectrum was taken within six hours of the initial event. The observations are consistent with a shell of material surrounding the star out to a distance of about 1015cm – that is a little more than 66 times the Earth-Sun distance. Models indicate that the bulk of this material was ejected within the last few hundred days of the stars life. However, because the velocity of the gas cloud around the star could not be directly measured, it is still difficult to decouple the effects of a short burst of mass loss right before the supernova event from longer-term, slower mass loss due to a stellar wind over hundreds of years. By: Alison Klesman

How researchers use solar pressure to study our own star — and maybe reach interstellar space 16 February: Light can exert pressure, a fact the $100 million Breakthrough Stardust project aims to harness for interstellar journeys. Now researchers suggest that sunlight applies pressure on the Sun itself, which could help solve the longstanding mystery of why the Sun's outermost parts spins unexpectedly slowly.


NASA/AIA

Light does not exert much pressure, but scientists have long suggested that what little it does apply could have a major effect. For example, in a letter to Galileo Galilei in 1610, Johannes Kepler wrote, "Given ships or sails adapted to the breezes of heaven, there will be those who will not shrink from even that vast expanse." Indeed, numerous experiments have shown that ‘solar sails’ can rely on sunlight for propulsion, given a large enough mirror and a lightweight enough spacecraft. Going one step further, the Breakthrough Starshot initiative announced by billionaire Yuri Milner in 2016 aims to use giant lasers to launch swarms of tiny spacecraft on interstellar voyages at speeds of roughly 20 percent that of light to reach the nearest star system to the sun, Alpha Centauri, in approximately 20 years, give or take.

Now scientists have found that sunlight can not only propel spacecraft outward, but also push down on the Sun. This may help solve a decades-old mystery regarding the sluggish nature of the skin of the Sun. Scientists can deduce the inner workings of the Sun by looking at tiny rhythmic fluctuations in its brightness that are due largely to sound waves ricocheting inside the star. By measuring the speed of these sound waves, researchers can generate 3-D maps of the solar interior, a technique known as helioseismology that works on the same principle as medical ultrasound, the method that allows doctors to capture pictures of a foetus inside a pregnant woman.

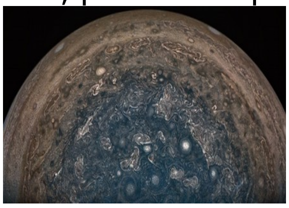
Roughly 30 years ago, scientists used helioseismology to measure the rates at which the Sun rotates. "That's when we realised that its rotation was more complicated than anyone imagined," said study co-author Jeff Kuhn, a physicist at the University of Hawaii in Maui. For example, while the inner 70 percent of the Sun rotates as one like a solid body, its outer regions are turbulent, convecting like boiling water. "That's a mystery we're only now understanding through large-scale numerical simulations," Kuhn said. In addition, in the Sun's outer parts, the equator spins faster than the poles. "That also seems to be caused by turbulent interactions," Kuhn said. Another mystery about the Sun came to light about 20 years ago, when helioseismology revealed that the outer 5 percent of the Sun "was slowing down everywhere, at both the equators and the poles," Kuhn said. "None of the big simulations got that result - it didn't seem to be the result of convection."

For a decade, Kuhn and his colleagues have focused on the outermost skin of the sun. Analysing data from the Helioseisimic and Magnetic Imager on NASA's Solar Dynamics Observatory, they found that in the outer 100 kilometres of the roughly 1.4-million-kilometre wide Sun, they unexpectedly saw a slowdown in speed of 2 or 3 percent compared with the rest of the Sun. Turbulence could not explain this surprising drop in speed, "because the outer couple of hundred kilometres of the Sun are not turbulent at all," Kuhn said. Instead, the researchers wondered if an answer might come from how this outermost region "is the layer of the sun that is radiating all of the light that we see from the Sun," Kuhn said.

The research team's calculations now reveal that sunlight is putting the brakes on the rotation of the surface of the Sun. Although this effect is small, over the roughly 4.6-

billion-year lifespan of the sun, "that slowdown can have a big influence and propagate inward," Kuhn said. "The slowdown we see turns out to be exactly what one would expect from the total energy the sun radiates." The propulsive effects of light can be seen not only with solar sails, but also with so-called 'zodiacal dust' that orbits the Sun. When these dust particles absorb sunlight, they emit light back out, which applies a push that slows these particles down and causes them to spiral inward toward the Sun, Kuhn said. "In an analogous way, the outer layer of the sun is radiating energy and slowing down. It's kind of fun to find a physical effect that was overlooked for a long time." By: Charles Choi

Juno will remain in its current orbit around Jupiter 17 February: The craft was originally supposed to insert into a perilous path skimming near the planet in a polar orbit. Alas, poor Juno's polar orbit.


NASA/JPL-Caltech/SwRI/MSSS/John Landino

NASA's Jupiter orbiter, which arrived at our largest planet in July, has been given new mission parameters: stay in its 53-day orbit instead of burning into a 14-day polar orbit. At perijove, the closest point to the planet, it skims just 2,600 miles (4,184 km) above the top layer of clouds. The probe then measures the weather and magnetic fields of the planet, trying to determine the interior of the planet. Because the craft flies over the ecliptic of Jupiter, it poses little risk of collision with any of the Jovian moons.

A planned thruster firing in August went awry. That would have shrunk the orbit down, with a second burn bringing it closer to a roughly circular orbit so close that it would have fried the imaging instrument. The rest of the instruments are buried in a radiation-proof 'vault' deep within the probe. Another attempt in October was thwarted by faulty helium valves, leading the team to skip a third attempt in October at perijove.

By staying in the 53-day orbit, NASA says they will be able to get 'bonus science' out of the mission, including the effects of its powerful radiation belts moving outward from the planet. This will also allow the team to perform an extended mission. If approved, Juno would continue to gather science on the planet and add to the body of evidence needed to determine whether the core of Jupiter is a fluid or a solid in nature. Initially, after its mission was complete in 2018, the craft was going to plunge into Jupiter for a final view.

By: John Wenz

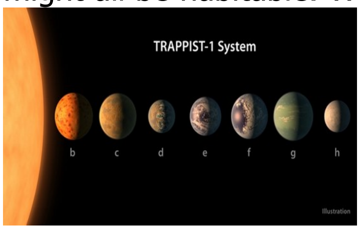
Scientists are months away from peering into black holes for the first time 17 February: The Event Horizon Telescope Array is almost certainly one of the most geographically widespread array telescopes ever built: spanning four continents, including Antarctica, the array taps into the potential of the Atacama Large Millimetre/submillimetre Array along with around a dozen other telescopes. The goal? To image a black hole for the first time.


ESO

Scientists have discovered plenty of black holes, but the evidence has always been indirect. For instance, Cygnus X-1, the first discovered stellar mass black hole, gives away its presence by cannibalising a nearby star and firing back hot jets of gas visible in X-ray, and many supermassive black holes are inferred either through gravitational influence or unlikely stars getting sucked into tidal disruption events. It is sort of like watching a small ship sink without being able to see the whirlpool in the ocean taking it down.

However, by enlisting an array of telescopes, the Event Horizon Telescope will utilise very long baseline array interferometry to measure perturbations in gas around Sagittarius A (Sag A), the black hole at the centre of our galaxy. In very long baseline array interferometry, the arrival of photons from Sag A will come at different times, with each telescope measuring the same event. By reconstructing what each telescope sees, a picture can emerge of whatever is happening at the centre of the galaxy. Then, for the first time, we will see inside a black hole instead of witnessing its effects, which will help astronomers answer questions about behaviours of these voracious beasts. The campaign begins in April. By: John Wenz

This tiny solar system packs in seven Earth-size planets 22 February: TRAPPIST-1 has a solar system like no other. The tiny, tiny red dwarf is just barely big enough to be considered a star and is, radius-wise, a hair bigger than Jupiter. When it was announced last May there was some excitement: the system had three Earth-sized planets and they might all be habitable. We are going to have to revise that, though. It has seven planets.



NASA/JPL-Caltech

TRAPPIST-1 is so small that it resembles Jupiter and its planets appear more like the Jovian moons when laid out distance-wise. TRAPPIST-1b has an orbital period of just 1.5 days and orbits at 1 percent the distance between the Sun and the Earth. Because TRAPPIST-1 is so small, though, instead of dooming the planet it could give it just a slightly balmier-than-comfortable temperature.

The May 2016 events which led to the initial discovery of the planets actually ended up being somewhat in error. Planets TRAPPIST-1b and TRAPPIST-1c were easily confirmed, but TRAPPIST-1d was not. TRAPPIST-1d had a bizarre, hard to constrain orbit much longer than the other planets, and was believed to potentially have an eccentric orbit. There was no TRAPPIST-1d. Or at least not as it appeared. Two transits were witnessed during the first observing campaign, both believed to be the outermost of the three worlds. However, those two transits were actually two distinct events. "The first transit and the second transit were coming from different planets," Michaël Gillon, a professor at the University of Leige and lead author of the paper, said. "In fact, the second transit was two planets passing at the same time."

That brings us to five planets. Intensive studies using both the TRAPPIST telescope and NASA's Spitzer telescope helped refine the orbit of the planets and drew out the presence of two more from the data. TRAPPIST-1b, -1c, -1f, and -1g are all very slightly larger than Earth. -1e is slightly smaller than Earth. -1d and -1h are closer to Mars in size. While the exact masses and orbital periods are not known yet, preliminary results suggest that they may be in resonance. That means that when -1b orbits eight times, -1c completes five orbits, often marked as 8:5. -1c and -1d are in 5:3 resonance; -1d and -1e are in 3:2, as are -1e and -1f. -1f and -1g are in 4:3.

All of them seem to be in the habitable zone of TRAPPIST-1. That means that they could, under the right conditions, sustain surface water, but there is no proof that any of the planets do. For instance, in our solar system, Venus and Mars are in the habitable zone, but both are fairly inhospitable in our present time. Of the seven, the researchers believe that -1e, -1f, and -1g are the likeliest to be habitable based on where they sit in the solar system.

There are other considerations before we declare the planets quite ripe for life, though. M-dwarf stars like TRAPPIST-1 tend to start out very active with high energy flare events. This could strip away the atmosphere of young planets. At this point, according to co-author Emmanuël Jehin, most comets would have been cleared out of the system and thus unable to replenish the atmospheres. However, other forces like volcanism could work to stabilise the atmospheres, strengthening them against the relentless flare events. M-dwarfs finally settle down after the first 3 billion years or so, though many stellar events still occur. For instance, Proxima Centauri is an active flare star, which could doom its habitable zone planet, Proxima Centauri b, from ever forming complex life. However, TRAPPIST-1 is cooler and less active than Proxima. "If you compare it Proxima Centauri, it's much less, but if you compare it to the Sun, it's much more," Gillon said.

TRAPPIST-1 and its seven (!!!) planets are high on the list of planets to be observed by the James Webb Space Telescope (JWST) after it launches next year. A follow-up telescope to TRAPPIST, SPECULOOS, will be able to find more TRAPPIST-type objects. TRAPPIST itself only looked at 50 ultracool stars for planets, while SPECULOOS will look at tens of thousands. JWST will monitor transits of worlds in the TRAPPIST stars, hoping to capture a glimmer of their atmospheres. If they seem to be thin and water-dominated, we may indeed be looking at a quite Earth-like planet. Or even three of them."We have seven targets that we can study in great depth, and they can give us a completely new insight into planet formation and stellar history," de Wit says. By: John Wenz

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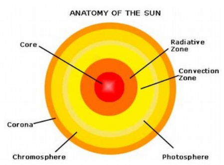
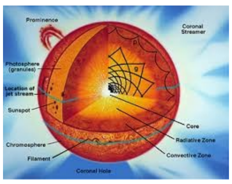
DID YOU KNOW?

The Sun Part 11: **Sun – structure 1**





The Sun has a layered structure.

Core This extends from the centre to about 25% of the radius. Its temperature is around 15.7 million K and its density up to about 150 times that of water. It is the area in which nuclear fusion takes place, producing over 99% of the Sun's energy. The remainder of the Sun is heated by this energy, which is transferred outwards through many successive layers to the surface before escaping into space as sunlight, the kinetic energy of particles.

Peak power production is actually quite low, power density being closer to a reptilian metabolism than a thermonuclear bomb. The huge power output is not due to high power per volume, but a consequence of the Sun's large size. The fusion rate in the core is a self-correcting equilibrium – increased fusion increases core temperature, causing expansion against the outer solar layers. This pressure then reduces the fusion rate, correcting the perturbation. The slower rate cools and slightly shrinks the core, increasing fusion rate, and so on.

Radiative zone This extends from the outer core to about 70% of the Sun's radius. Thermal radiation, rather than convection, is the main means of energy transfer in this layer, and temperature drops from around 7 million to 2 million K with increasing distance from the core. Density drops 100 times from the core to the outer edge of the zone.

The high energy gamma ray photons released by nuclear fusion in the core are almost immediately absorbed by the solar plasma in the zone, usually after travelling only a few millimetres. Re-emission is in random directions and usually at slightly lower energy. This sequence of emissions and absorptions continues, and it takes a long time for radiation to reach the Sun's surface. Photon travel time estimates range from 10,000-170,000 years. By contrast, neutrinos (2% of total energy production in the core), take only 2 to 3 seconds to reach the solar surface. This is because they rarely interact with matter and are able to escape almost immediately.

Tachocline This is the transition layer between the radiative and convective zones. A large shear results where the uniform rotation of the radiative zone changes to the differential rotation in the convective zone. Successive horizontal layers slide past one another, the fluid motion of the convective zone above slowly disappearing from the top of the layer to its bottom, matching the calm characteristics of the radiative zone at its base. It is hypothesised that a magnetic dynamo within this layer generates the Sun's magnetic field.

Convective zone This occupies the outer 30% of the Sun, from its surface to about 200,000 km below. Temperatures are lower than in the radiative zone and heavier atoms not fully ionised, making radiative heat transport less effective. However, at these temperatures, plasma density is low enough to allow convective currents to develop.

Material heated at the tachocline expands, reducing density and rising. Thermal convection develops as thermal cells carry the majority of the heat outward to the photosphere. At the solar surface, temperatures have dropped to around 5,700 K and density to that of air at sea level.

Turbulent thermal columns in the zone form mottling imprints on the Sun's surface. The numerous small, light areas are called granules. They are separated from one another by darker, cooler intergraunular lanes. Reflecting the dynamic process underlying their formation, individual granules last only around 20 minutes.

Photosphere This is the outer, visible surface of the Sun, Beyond the photosphere, the energy of sunlight is free to propagate into space. Varying in depth from 10 -100s of km, the photosphere is slightly less opaque than air on Earth, with a particle density of around 0.37% of the particle numbers per volume of Earth’s sea level atmosphere. The average temperature of the solar surface is around 5,700 K. The upper part is cooler, temperature steadily decreasing to about 4,400 K at the so-called temperature minimum.

Temperature minimum This forms the boundary between the photosphere and the solar atmosphere and is located about 550 km above the base of the photosphere.

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

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