"The Southern Cross"

HERMANUS ASTRONOMY CENTRE NEWSLETTER

OCTBER 2017

**This month's Centre meeting**
This will take place on **Monday 16 October** at the **Catholic Hall** starting at **19.00**. Centre member, Jenny Morris, will be talking about 'Jupiter: the neighbourhood bully' See below for more details.

## WHAT'S UP?

**A bright collection of ancient stars** Low in the south-west (west of the Small Magellanic Cloud) lies the constellation of Pavo (the peacock). In Greek mythology, the peacocks which drew the chariot of Hera, Zeus' wife, were sacred to her. Only visible south of 15°N, it was discovered in the 1500s by Keyser and de Houtman, Dutch navigator-astronomers. Pavo contains one of the largest and brightest globular clusters, just visible to the naked eye and best viewed through binoculars. NGC 6752 is outshone only by Omega Centauri and 47 Tucanae. It was discovered in 1826 in Australis by James Dunlop. Located around 13,000 ly away, it is estimated to be 11.8 billion years old and to contain at least 100,000 stars. It has a very concentrated core. Like other globular clusters, NGC 6752 contains some of the oldest stars in the Milky Way. Their characteristic spherical shape with most mass concentrated at the centre, reflects how tightly they are bound by gravity. Around 160 globular clusters have been identified. Unlike the younger stars which form the disk of the Milky Way, these much older structures are found in the halo which surrounds the galaxy. Their great age is confirmed by the absence of any active stellar formation taking place within them, and by the absence of any of the gas and dust needed for star formation. In many globular clusters, the stars are of similar age, suggesting that they were formed at the same time.

## LAST MONTH'S ACTIVITIES

**Monthly centre meeting** The presenter on 18 September was Dr Michelle Cluver, Associate professor, Associate Director of IDIA (Inter-University Institute of Data Intensive Astronomy), and an NRF Research Career Advancement Fellow at the University of the Western Cape. Her engaging and thought-provoking talk was on 'Hidden features: discovery science in a reluctant Universe'. Using examples from both biochemistry and astronomy, Michelle began by illustrating how fundamental or 'blue sky' research can lead to very practical outcomes like Wi-Fi, which justifies the time and costs involved in undertaking it. She then summarised the serendipitous discoveries which led to the establishment of radio astronomy as a core tool in astronomy and described how it has enhanced her work on galaxy clusters. She explained, particularly, how observing

Stephan's Quintet with optical, infrared and radio telescopes has enabled her and others to explain their findings of both hot and cold hydrogen within the cluster, work which has added to astronomers' and cosmologists' understanding of the role of the most abundant element in star and galaxy formation and behaviour over time. She finished her presentation with an explanation of how much more will be able to be learned about the present and past Universe from the large scale radio telescopes like SKA which are currently under construction or recently completed.

## Interest groups

**Cosmology** 14 members attended the meeting on 4 September. They 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 15 'The November revolution of 1974' and Lecture 16 'A new generation'.

**Astro-photography** At the meeting on 11 September, members continued considering nebulosity in processing their own astro-images.

## Other activities

**Educational outreach**

**Hawston Secondary School Astronomy Group** Meetings have stopped for the remainder of the year, as the learners are preparing to write Matric exams.

**Lukhanyo Youth Club** No meetings are being arranged while members are attending a series of workshops being run by SANSA staff during 2017.

**Science workshops** On 31 August, Pierre de Villiers and Johan Retief led one of a series of workshops being given to Overberg science teachers and learners during the year. Johan reports: 'The workshop, held at SANSA, was attended by educators from Gansbaai Primêre Skool (2), Lukhanyo Primary School (2), Zwelihle Primary School (4) and Umyezo Primary School (2). 21 learners from the various schools also attended the workshop. Pierre de Villiers opened the workshop with a slide presentation on how a sundial work and different types of sundials. He handed out workshop packs consisting of documentation as well as a CD with a presentation on sundials. He explained how to construct an analemma sundial and requested the educators to oversee the construction of such a sundial at their schools.

I showed the workshop how to fold a printed paper to make a horizontal sundial. Andile (SANSA) then showed and assisted the group in making armillary sundials with the help of printed diagrams provided to us by Case Rijsdijk (Garden Route Astronomy Centre). On completion, the group visited SANSA's sundials (a horizontal as well as an armillary sundial) to see how to tell the time and to test the horizontal sundial that the made with the Sun's shadow. On the whole, great fun was had by all who attended the workshop and this learning experience.'

**Youth group visit** On 23 September, Pierre de Villiers and Johan Retief were joined by members of the Lukhanyo Youth Group (15) and the Hawston Space Cadets (9) for an astronomy and science day in Cape Town. Time to enjoy the interactive exhibits at the Science Centre in Observatory was followed by a visit to Signal Hill to experience firing of the noon gun, and to eat their lunches. Then they attended a show using the new digital projector at the Iziko Planetarium in the Gardens before travelling to the South African Observatory, where they were taken on a tour of the facilities and grounds. Unfortunately, the hydraulic floor of the McLean telescope was not operating, but it did not detract from the learners experiencing a stimulating and very enjoyable day.

## THIS MONTH'S ACTIVITIES

Monthly centre meeting This month's meeting will take place on **Monday 16 October** at the **Catholic Hall** starting at **19.00**. The speaker is Centre member, Jenny Morris. She says about her talk, titled 'Jupiter: the nieghbourhood bully': 'Jupiter's size and mass means that it dominates the solar system. Amongst other consequences, it decides the course and destination of any smaller objects which venture near it, its magnetosphere reaches Saturn (650 million km away), and its hurricanes last for centuries. Jupiter also played a central role in the formation of the solar system, pushing other planets around and scattering smaller objects in its wake as it meandered around the young Sun. On the other hand, like other bullies, it has its weaknesses. It might have lost its core, and it is shrinking a little every year. The talk will consider all these and other interesting features which characterise this gas giant.'

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 **2 October** at the **Catholic Hall**, starting at **19.00**. Attendees will watch the next two episodes in the DVD series: Particle Physics for Non-Physicists: a Tour of the Microcosmos' by by Prof Steven Pollock, Professor of physics at the University of Colorado at Boulder. The content will be Lecture 17: 'Weak forces and the standard model' and Lecture 18: 'The greatest success story in physics'.

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 **9 October**. Members will continue to 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 are progressing with work towards accessing images which learners can start processing with suitable software.

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

## FUTURE ACTIVITIES

The trip to SKA near Carnarvon, from 23-25 November, has been advertised to members, and is fully booked. If you wish to put your name on the waiting list, please e-mail John Saunders at antares@hermanus.co.za

## 2017 MONTHLY MEETINGS

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

| | |
|---|---|
| 16 Oct | 'Jupiter: the neighbourhood bully' Presenter: Jenny Morris, Committee member |
| 20 Nov | 'The mystery of the black aurora' Presenter: Amore Nel, SANSA |
| 11 Dec | Xmas party |

## 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 single strange repeating fast radio burst is at it again** 5 September: Fast radio bursts (FRBs) are one of the hottest topics in astronomy right now. These intense blasts of radio energy reach from outside the galaxy, lasting only milliseconds before they disappear once more. Astronomers are not sure what causes them, and none of these bursts has ever repeated - except one, FRB 121102, which made headlines with the identification of its host galaxy, sitting nearly 3 billion light-years away. The Breakthrough Listen project has just announced the detection of 15 additional bursts from FRB 121102, which has now been seen to repeat more than 150 times.

Fifteen new bursts may not seem unique among such a high number, but these bursts are different. They are the first time that FRB 121102 has been seen bursting at high frequencies; and they also signal, according to Vishal Gajjar of the University of California, Berkeley, a "newly active state". On 26 August, Gajjar was observing FRB 121102 using the Green Bank Telescope in West Virginia as part of Breakthrough Listen and detected 15 new pulses over the course of five hours. The brightest burst occurred at about 7 GHz, a higher frequency than any pulse observed from an FRB before.

The results come from a dataset 400 terabytes in size, covering frequencies from 4 to 8 GHz. "The high resolution of the data obtained by the Listen instrument will allow measurement of the properties of these mysterious bursts at a higher precision than ever possible before," said Gajjar. "The extraordinary capabilities of the [Breakthrough Listen] backend receiver, which is able to record several gigahertz of bandwidth at a time, split into billions of individual channels, enables a new view of the frequency spectrum of FRBs, and should shed additional light on the processes giving rise to FRB emission."


The 100-meter Robert C. Byrd radio telescope at the Green Bank Observatory is part of the Breakthrough Listen project. Jiuguang Wang (flickr)

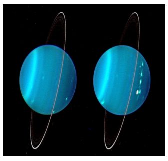
FRBs, including FRB 121102, are still mysterious events. Astronomers do not know where they come from, but the repeating nature of FRB 121102 does help by indicating that at least some FRBs, such as 121102, cannot be cataclysmic events. Such an event, which would destroy its progenitor, would not allow for repetition over time.

Currently, one of the leading theories outlines the source of FRBs as highly magnetised neutron stars, called magnetars, which may experience outbursts related to starquakes or magnetic field events. On the other end of the spectrum, FRBs could potentially be directed energy signals used by extraterrestrial civilisations to power spacecraft - a technique similar to that planned for Breakthrough Starshot, as well as the type of signal that projects such as Laser SETI will search for.

Regardless of their cause, these particular bursts left their home galaxy when our solar system was just 2 billion years old, and life on Earth was in the form of single-celled organisms. The team was able to determine their origin and distance by measuring the effects of dispersion on the signal, which allowed them to calculate the amount of material - and thus the distance - between Earth and the signal's source, whatever it may be.

By: Alision Klesman

**Uranus is a dangerous place for its moons** 11 September: Discovered in 1781, Uranus is an ice giant orbiting our Sun once every 84 Earth years. This mysterious world, which appears as just a tiny dot in most amateur telescopes, not only possesses a system of thin, faint rings, but also 27 moons (by our current count). However, at least one of those things is destined to change: new measurements indicate at least two likely collisions between four of the planet's moons millions of years in the future.


Uranus is one of the most distant worlds in our solar system Lawrence Sromovsky, University of Wisconsin-Madison/W.W. Keck Observatory

Robert Chancia at the University of Idaho and his colleagues set out to better understand Uranus' Eta ring. They discovered that the ring's shape is not perfectly circular, but, instead, it is triangular - and the cause of the distortion is the tiny moon Cressida, just 82 km across. Based on the size and shape of the distortion, the team was able to accurately measure Cressida's mass and density. They used these qualities to determine that gravitational interactions between Cressida and other nearby moons will mean a collision between Cressida and another moon, most likely Desdemona, is imminent. The collision between Cressida and Desdemona, currently orbiting just 900 km apart, is likely to take place within the next million years.

Furthermore, they are not the only two moons destined for doom: In 2012, SETI Institute researchers Robert French and Mark Showalter determined that the moons Cupid and Belinda are likely to collide between 10 and 1,000 million years from now. These future collisions seem even more probable when viewed in light of two diffuse rings around the planet today that likely formed from the debris of previous collisions between now-long-gone moons. By: Alison Klesman

**New Horizons is awake again** 13 September: NASA's New Horizons spacecraft is awake - temporarily - for a short burst of activity while on its way to its post-Pluto target in the Kuiper Belt, an object known as 2014 MU69. The spacecraft was put into hibernation mode on 7 April to save power on its long journey, which is not yet complete. Now that it is awake, the mission team will begin performing instrument checks and data collection for the next three months, as well as an additional flight path correction, before the spacecraft is returned to hibernation until it is ready to encounter MU69 in 2019.

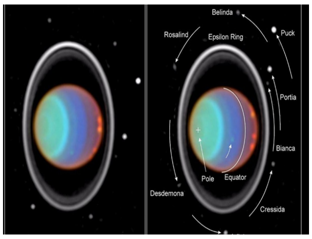

New Horizons will fly by 2014 MU69 in January 2019; encounters it.NASA/Johns Hopkins University Applied Physics Laboratory/Southwest Research Institute

There are several reasons to place a spacecraft in hibernation: it reduces the operating cost of the mission and reduces the amount of wear and tear that on-board instrumentation and computing systems undergo. During the hibernation period, however, the spacecraft's flight computer continued to actively monitor its sleeping systems, pinging Earthbound teams with a status report each week. On 22 December, New Horizons will re-enter hibernation mode, with a slated wakeup date of 4 June 2018. After that, its systems will remain active in anticipation of its MU69 encounter on New Year's Day, 2019.

MU69 orbits the Sun over 6.5 billion km from Earth, and it is an additional 1.5 billion km jaunt past the Pluto system. Although New Horizons is heading for the Kuiper Belt object now, the mission operations team will complete one further course correction on 9 December, which will lock in the final date and time of New Horizons' encounter with the mysterious world (or worlds - a recent occultation revealed that MU69 may be two bodies orbiting each other closely).

Prior to shutting down in April, New Horizons had been functioning continuously since before its Pluto flyby in July 2015. New Horizons is now more than 5.8 billion km from Earth, and will come within 3,500-10,000 km of MU69 during its nine-day flyby in 2019.

That flyby will be the farthest planetary encounter in human history, and reveal much more about the Kuiper Belt than astronomers are able to glean from Earth.



The Hubble Space Telescope spotted eight of Uranus' moons while tracking clouds in the ice giant's atmosphere. Cressida and Desdemona are fated to collide in about a million years. NASA/JPL/STScI

Determining Cressida's fate was not originally the goal of the study. The team initially set out to find the cause of the Eta ring's distortion, which orbits the planet much faster than the individual particles in the rings. The speed of the distortion, they found, instead matched the orbital speed of Cressida, linking the two together as cause and effect. As a result, Chancia and his colleagues made the first mass measurement of the moon, finding Cressida is about 1/300,000th the mass of Earth's Moon and has a density 86 percent that of water. This actually makes Cressida denser than many of Saturn's small moons, indicating that it likely contains a decent amount of rock as well as water ice.

Although several of the planet's moons are slated to someday collide, the impending collisions may not completely destroy the moons involved. If that happens, Uranus could end up with 'new' moons that future astronomers refer to as Cupbel and Cresdemona.

By Alison Klesman

**Cassini meets its end** 15 September: Just shy of 20 years ago, the Cassini craft set out for Saturn. Today, it was intentionally destroyed in Saturn's atmosphere to preserve two potentially habitable moons.


The Cassini spacecraft streaked into the atmosphere of Saturn after more than a decade exploring the planet and its system of rings and moons. NASA/JPL-Caltech

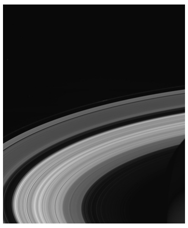
The 15 October 1997 launch marked a continuation of the Pioneer and Voyager programs' first reconnaissance of those worlds. At the time, there were some concerns about the spacecraft's Radioisotope Thermoelectric Generators (RTGs) re-entering Earth's atmosphere if something went wrong during a scheduled gravity assist in 1999.

It took two Venus flybys and a final push from Earth to get the massive spacecraft, which had been launched aboard a meagre Titan IV Centaur, on the trajectory it needed for its seven year voyage toward Saturn. In 2000, it passed by a small asteroid named 2685 Masursky, revealing the 15-20 km main belt body on its way. A final boost from Jupiter later that year gave Cassini what it needed to arrive at Saturn in 2004.

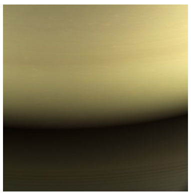
The craft arrived in June 2004, inserting itself into orbit in July. In December 2004, it dropped the Hugyens probe near Titan; the moon eventually captured the probe and dragged it into its dense atmosphere in January 2005 and studied the bizarre, planet-sized moon.


Cassini snapped this picture of Jupiter and its moon Io as it passed the giant planet at a distance of 10 million km. Cassini Imaging Team, SSI, JPL, ESA, NASA

From there, it detailed 24 of Saturn's 62 moons (some of which it spotted for the first time), discovered new rings, found evidence of at least three ocean worlds, saw geysers on Enceladus (confirming suspected geological activity), and returned some of the most beautiful images of any spacecraft. It also took a few pictures of our own planet and moon, magnifying our smallness in the grand scheme of the Universe.


Taken 13 September, this image of Saturn's rings is one of the last photos ever snapped by Cassini. NASA/JPL-Caltech/Space Science Institute

This morning, confirmation of the end of Cassini's long mission came at 11:55 UTC. The last signal from the spacecraft was received in Canberra, Australia, which had rotated to face Saturn as the spacecraft plunged into the planet's atmosphere. Cassini's end actually came 83 minutes prior to loss of signal, as it had taken over an hour for that signal to reach Earth from Saturn, 1.4 billion km away.


One of  the last images ever taken by Cassini, showing its impact site on Saturn. NASA/JPL-Caltech/Space Science Institute

Initial results indicate that, as planned, Cassini's thrusters were firing as it entered the atmosphere. It sent back data taken with eight of its instruments from within that atmosphere for about a minute between entry and loss of signal. That data will provide a unique and up-close look at the gas giant's atmosphere, including magnetic field, temperature, composition, and plasma density. Cassini's last images from the Saturn system were sent before it entered the atmosphere. Telemetry received during the plunge indicates that, as expected, Cassini entered Saturn's atmosphere with its thrusters firing to maintain stability, as it sent back a unique final set of science observations.

For now, the Jupiter probe Juno is the lone craft in the 'second zone' of the solar system, which contains the gas and ice giant planets and their approximately 170 moons. Juno is expected to meet a controlled destruction into Jupiter next year. There are rumblings of missions to Uranus and Neptune, but those are decades away. The Voyager crafts, weakly functioning but still alive, are speeding out of the solar system as fast as they can go, tasting the constituent particles of interstellar space. New Horizons is skimming through the Kuiper Belt toward a primordial body called 2014 MU69. Sometime in the 2020s, the Europa Clipper will, with all hope, arrive in the Jupiter system and detail its four massive moons, focusing on the ocean beneath Europa. Ganymede is believed to have an ocean as well, something the craft may confirm. But any plan to return to the Saturn system is far off and likely to focus on Enceladus and Titan — there are at least three proposals to explore these worlds. This may leave some of the other fascinating moons like Dione, another ocean world, in the dust.

Cassini's final moments left us with parting pictures of Enceladus and Titan, new studies of the rings and a phenomenon called 'ring rain', and spectacular details of the upper atmosphere of Saturn before it met its demise, ripped apart and burned up by Saturn's atmosphere in a space of about two minutes. It was out of fuel and NASA could not risk it colliding with an ocean world and contaminating it with Earth bacteria. By: John Wenz

**Is our galaxy normal?** 20 September: Our home galaxy, the Milky Way, has been a jumping-off point to our understanding of galaxies throughout the Universe. Our picture of that home galaxy has evolved over time as astronomers have developed better ways to catalogue and map its contents and we have largely believed the Milky Way was a 'typical' example of a spiral galaxy. Now, astronomers are taking steps to determine whether that is really true.

New data from the Satellites Around Galactic Analogs (SAGA) Survey is reshaping our picture of the Milky Way by studying galaxies like it. The Milky Way has a slew of smaller 'satellite' galaxies bound by gravity, many of which are in the process of falling into and becoming part of our larger galaxy. But the SAGA survey, which has studied eight Milky Way-like galaxy systems in the past five years, has revealed that our satellites are much calmer - as in, less luminous and making fewer stars - than those of our 'siblings'. If this trend is confirmed, it may assist understanding of whether the Milky Way is normal or not.

"Our work puts the Milky Way into a broader context," said Risa Wechsler, a SAGA member and researcher at the Kavli Institute at Stanford University. Marla Geha, a researcher at Yale University, added, "Hundreds of studies come out every year about dark matter, cosmology, star formation, and galaxy formation, using the Milky Way as a guide. But, it's possible that the Milky Way is an outlier." If so, it would affect our understanding of other galaxies, as seen through the lens of our own. Thus, itis vital to determine, "whether the Milky Way is unique, or totally normal. By studying our siblings, we learn more about ourselves," she said. So far, those siblings appear to have systems of satellite galaxies actively forming new stars, and glowing brightly as a result. That is not the case around the Milky Way, which is leading astronomers to wonder whether our galaxy is truly the 'normal' benchmark we believe it to be.

In all, the SAGA survey will look at 100 Milky Way 'sibling' systems. The current sample of eight, while showing a trend in satellite galaxy activity and luminosity, is still too small to draw solid conclusions. Over the next two years, the survey plans to add 25 more siblings to their dataset, which should improve astronomers' ability to discern trends about the Milky Way and similar galaxy systems. Armed with that knowledge, astronomers can begin to determine whether our models of galaxy behaviour - largely based on our understanding of our home galaxy - are reliable, or whether they may require updating because they're based on an abnormal example. By: Alision Klesman

**So, when do we get to go back to Saturn?** 26 September: Cassini's mission is over and gone for good. However, we are not done with Saturn yet - it just may be a while before we go back. By the end of the year, NASA will decide on a new New Frontier-class mission. This medium-cost mission class is responsible for the Juno, New Horizons, and OSIRIS-REx probes, and has a handful of finalists selected for a mid-2020s launch. Among proposals for a Moon mission, a Venus lander, and a comet sample return are five Saturnian missions.

The first one is a plunge directly into Saturn, studying the interior of the planet's cloud layers as it moves down. Cassini performed a sort of initial reconnaissance into Saturn's atmosphere, but broke apart quickly. The Saturn Probe Interior and Atmosphere Explorer would last longer - about an hour and a half. Then there are two competing proposals to explore Enceladus. One involves sending an orbiter through the plumes of Enceladus several times with enough instruments to detect organic chemicals and possibly life. The other proposal, Enceladus Life Signatures and Habitability, has been kept under a tight lid. Finally, there are two Titan proposals. One is an orbiter, looking for the best places to find life on Titan in greater detail than before, while the other would place an actual drone into Titan's atmosphere to explore the smoggy world.

NASA also has a class of missions called Discovery Class that are lower cost. The last round of proposals involved a joint mission to Enceladus and Titan, as well as two Enceladus explorers. NASA and ESA also worked together on a proposal called TSSM that may yet see the light of day, and a Titan boat is always just over the horizon.

Finally, NASA has a close-to-science-fiction class of studies called NASA Innovative Advanced Concepts. These are all technological demonstrations for missions 30 to 40 years down the line, but indicate in general where NASA's head is, cosmos-wise. Recent relevant proposals include submarines, hot air balloons, and a wheel-less rover that stumbles around like a tumbleweed. With any luck, we will be back at Saturn in the 2030s. There are just a few hurdles to overcome in the meantime. By: John Wenz

**Scientists catch another gravitational wave, and they know where it came from**
27 September: Last year, physicists made history by observing the first-ever gravitational wave. Their discovery confirmed Albert Einstein's century-old theory of gravity and capped decades of effort to build an instrument sensitive enough to catch these ripples in spacetime. Since then, researchers working at the government-funded Laser Interferometer Gravitational Wave Observatory (LIGO) - twin detectors in Louisiana and Washington State - have caught several more gravitational waves.

At a press conference in Italy, the team announced a fourth detection from two colliding black holes, each dozens of times more massive than the Sun. For the first time, they had the benefit of three gravitational wave detectors. Italy's version of LIGO - called Virgo - came online on 1 August following massive upgrades. It took just two weeks for the Italian gravitational wave detector to prove its worth.On 14 August, a gravitational wave passed over Earth at light speed, reaching Washington, then Louisiana and finally, Italy.

Compared to the other fundamental forces, gravity is actually very weak, so only extreme events like colliding black holes produce detectable waves. Those waves warp the very fabric of space, but are so tiny that they'd alter the distance between Earth and the sun by just the width of a hydrogen atom. Scientists were somewhat surprised that Virgo, which was still being commissioned, was already sensitive enough to detect gravitational waves.


VIRGO Wikimedia Commons

Having a third detector let the team use the time difference between the gravitational wave's arrival at each site to figure out exactly where the signal came from. They could already tell how far away the collision happened, but LIGOs twin detectors could only narrow the direction of origin down to a vast ring in Earth's sky - they could not tell where the signal was coming from. "That's very important to us," says LIGO physicist Jolien Creighton of the University of Wisconsin-Milwaukee.

It allows the LIGO collaboration to loop in more traditional telescopes so they can turn their instruments in that direction and search for a corresponding light signal. "The great advantage that having Virgo brings is it has now three different times, which allows you to triangulate to a point on the sky," Creighton says. "That brought the area it could have been from about 1,000 square degrees in the sky down to about 60 square degrees." For perspective, the moon covers less than one square degree of Earth's sky.

For example, with the gravitational wave last month, computers picked up on the signal less than a minute after it arrived at Earth. And 25 telescopes - everything from gamma and x-ray telescopes to neutrino observatories - then looked to see if they could see any light from these colliding black holes. Theory suggests that kind of collision would not put out any light, but if it did it could tell us something new about the cosmos.

Another advantage of Virgo's triangulation is that physicists were able to deduce how the gravitational wave was polarised. Einstein's general relativity theory only allows for two types of polarisation, but other theories imply gravitational waves could come in as many as six different polarisations. The gravitational wave's polarisation last month was one of the two that meshes with general relativity, providing yet another sign that Einstein got it right a century ago. By: Eric Betz

**MUSE used to study Saturn Nebula** 27 September: Planetary nebulae are a poorly named group of cosmic objects. That is because planetary nebulae have nothing at all to do with planets. Charles Messier discovered the first planetary nebula in 1764. But it was actually William Herschel, the discoverer of Uranus, who would go on to coin the term based on their round, planet-like appearance. They are old stars in their final death throes, formed when a star like our Sun reaches the red giant phase of its life.


With the help of the powerful MUSE instrument on ESO's Very Large Telescope (VLT), researchers were able to capture this beautiful image of the Saturn Nebula ESO/J. Walsh

The Saturn Nebula - located about 5,000 light-years from Earth in the constellation Aquarius (The Water Bearer) - is a complex planetary nebula that contains many morphological features that scientists would like to understand. This is why an international team of astronomers, led by Jeremy Walsh of the European Southern Observatory (ESO), used the Multi Unit Spectroscopic Explorer (MUSE) to peer inside the dazzling palls of the Saturn Nebula, producing the first detailed optical maps of a planetary nebula and revealing many of its intricate structures.

MUSE is installed on one of four Unit Telescopes that make up the Very Large Telescope at ESO's Paranal Observatory in Chile. It is an impressive piece of technology, and most of its power stems from the fact that MUSE not only creates a two-dimensional image of a target, but also gathers spectral data for each point in the image.

With this spectral information, the researchers can then filter the image by colour, revealing information about the complex morphology of the object and its chemical composition. In the case of the Saturn Nebula, the team found a plethora of intricate structures, including a thin elliptical inner shell, a football-shaped outer shell, a spherical halo, and two well-known ansae - the Latin term for handles. Most intriguingly, the researchers also found evidence of a mysterious wave-like structure within the dust of the Saturn Nebula. They found that just outside the rim of the inner shell, there is a notable drop in the amount of material, indicating it may be getting destroyed. Although the researchers are not sure what mechanism is destroying the dust and gas, the leading theory is that the inner shell is essentially a giant, expanding shock wave that is obliterating the dust as it travels outward. By using MUSE to map the complicated structures within planetary nebulae, scientists hope reveal the role gas and dust plays in the lives (and deaths) of these low-mass stars. By: Jake Clark

**Five places spacecraft will visit soon** 29 September: Our solar system is home to a wealth of unexplored and under-explored planets, moons, and more. Here's a look at five

**1. Mercury** ESA's BepiColombo craft is set to launch a year from now in October 2018 and head toward our innermost planet. Plenty of mysteries surround tiny Mercury, not the least of which is it seems to composed mostly of materials found in the cores of other planets. This means Mercury may have been the victim of a planetary pileup in which several planets collided and only Mercury made it out alive, leaving just a shell of its former self behind. If true, this may mean that Mercury was once the queen of the terrestrial planets - no small feat.

**2. Mars** The Mars InSight lander will launch in May 2018, heading to Mars to perform seismic studies. It will drill straight down into the martian soil and look for signs of present geologic activity. ESA's next ExoMars fleet will launch that same year to look for evidence of past or present life on the Red Planet. Finally, NASA will send its Mars 2020 rover there in 2020. The mission will act like a souped up version of the present Curiosity craft.

InSight NASA

**3. Europa** In 2022, NASA will launch the Europa Clipper mission toward Jupiter, inserting it into an orbit that will result in repeated encounters with Europa. This Galilean moon is believed to contain a massive ocean under its ice crust and may be one of the best places to find life outside of Earth. The Clipper mission may end up taking a lander along for the ride as well.

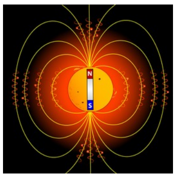
**4. Psyche** A protoplanet core may be hiding in plain sight in the asteroid belt. The Psyche orbiter is here to find out for sure. Named after its intended target, the craft will launch in 2022 for a 2026 encounter with the metal-rich asteroid Psyche. This world could be the key to unlocking how our solar system formed, and is one of the most unique objects in the solar system.

**5. Ganymede** Ganymede is the largest moon in our solar system - even larger than the planet Mercury and a good fraction the size of Mars. The Jupiter Icy Moons Explorer (JUICE) mission from ESA will launch in 2022 and study Europa, Ganymede, and Callisto before settling into an orbit around Ganymede. All three are thought to harbor oceans, though Callisto's may have the smallest volume of water. By John Wenz

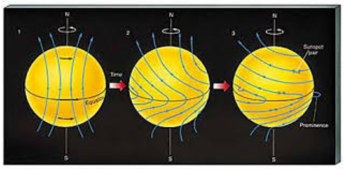
Source of these and further astronomy news items: www.astronomy.com/news

DID YOU KNOW?

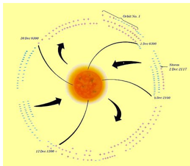
**The Sun** Part 19: **Magnetic field 1**




Solar magnetic field




Field line distortion causes sunspots



Solar magnetosphere

Like all stellar magnetic fields, that of the Sun is generated by the motion of the conductive plasma within it. This motion is created through convection, a form of energy transport involving physical movements of material. Field generation is believed to take place in the Sun's convective zone where the convective circulation of the conducting plasma functions like a dynamo, generating a dipolar stellar magnetic field.
In the solar dynamo, the kinetic energy of the hot, highly ionised gas inside the Sun develops self-amplifying electric currents which are converted into the solar magnetic field which gives rise to solar activity. This conversion is due to a combination of differential rotation (different angular velocity of rotation at different latitudes of a gaseous body), Coriolis forces and electrical induction. These rotational effects, and the fact that electrical current distribution can be quite complicated, influence the shape of the Sun's magnetic field, both on large and local scales.

In 1952, the American father and son solar astronomers Harold and Horace Babcock developed the solar magnetograph with which they made the first ever measurements of magnetic fields on the Sun's surface. Their work enabled them to develop a model which explains their extensive observations and spectrographic analysis of solar magnetic field behaviour. In this, from large distances, the Sun's magnetic field is a simple dipole, with field lines running between the poles. However, inside the Sun, the rotational effects which help create the field also distort the field lines. The result is that the poloidal (pole to pole) magnetic field lines under the photosphere become increasingly twisted until they are parallel at the equator (the toroidal field).

The local active regions of the Sun, including sunspots, are thought to be generated as these distorted magnetic field lines rise through the photosphere. In these areas of high distortion, particularly in the equatorial regions, the magnetic field can become highly concentrated, producing activity when they emerge on the surface. The localised field lines exert a force on the plasma, effectively increasing pressure without a comparable gain in density. As a result, the magnetised region rises relative to remainder of plasma until it reaches the photosphere. Where it breaks through the surface, the magnetic field lines create coronal loops on the surface, and the related phenomenon of sunspots. Coronal loops are magnetic flux tubes which are formed within the convection zone. Filled with hot plasma, they form arches extending upwards from the photosphere into the corona. It is theorised that these loops contribute to the very high temperatures found in the corona. The two ends of the loop, the footprints, are located in regions of the photosphere of opposite magnetic polarity to each other.

Sunspots are regions of intense magnetic activity on the Sun's surface. They form a visible component of magnetic flux tubes. Due to the differential rotation of the star, these tubes become curled up and stretched, inhibiting convection. This creates zones of lower than normal temperature, explaining why sunspots are visibly darker than the surrounding photosphere. Solar magnetic activity is also associated with short term, but explosively energetic surface events including solar flares and coronal mass ejections.

Another feature of the solar dynamo model is that the electric currents are alternating, not direct. This means that their direction, and thus the direction of the magnetic field they generate, alternates more or less periodically, changing amplitude and direction, although still aligned closely with the axis of rotation of the Sun. This explains the existence of the 11-year solar cycle.

Surface activity appears to be related to age and rotation rate of main sequence stars like the Sun. Young stars with rapid rotation rates exhibit strong activity, while middle aged, stars, lie the Sun, with slower rotations rates show low levels of activity that vary in cycles. Some older stars display almost no magnetic filed related activity,

**Magnetosphere** Stars with a magnetic field generate a magnetosphere that extends outwards into surrounding space. The field lines originate at one magnetic pole and end at the other pole, forming a closed loop. The magnetosphere contains charged particles trapped form the solar wind which then move along the field lines. As the star rotates, the magnetosphere rotates with it, dragging along the charged particles, creating a torque on the ejected matter.

This results in transfer of angular momentum from the Sun to surrounding space, causing slowing of its rotation rate. However, like other stars, rotation will never cease. Rapidly rotating stars have a higher mass loss rate, resulting in faster loss of momentum. However, as the rotation rate slows, so does angular deceleration. By this means, the Sun, like other stars will gradually approach, but never quite reach, a state of zero rotation.

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

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

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