"The Southern Cross"

# HERMANUS ASTRONOMY CENTRE NEWSLETTER

## JANUARY 2019

We wish all our members a Happy New Year, and all the best for 2019.

**Monthly meeting** This month's meeting will place on **Monday 21 January** at the **Catholic Church Hall** starting at **19.00.** Dr Amanda Sickafoose from the SAAO will be talking on 'Recent results from the outer Solar System'. See below for further details.

**Membership renewal for 2019**

There will be a small increase in the fees for 2019, following 2 years at the current rate.

The 2019 fees are as follows:

Member: R160

Member's spouse/partner/child, student: R80

New members joining after 1 October 2018 will have membership until the end of 2019.

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.

**2019 monthly meeting dates** For your diaries. Meeting dates will be 21 Jan 18 Feb, 18 Mar, 15 Apr, 20 May, 24 Jun, 15 Jul, 19 Aug, 16 Sept, 21 Oct, 18 Nov and 9 Dec. The provisional list of topics and speakers is detailed below.

## WHAT'S UP?

**Moon near Aldebaran** The moon passes through Taurus constellation during the middle days of the month. On the 17th, it is very close to the brightest star, Aldebaran (Alpha Tauri), which forms part of the inverted V-shaped Hyades open cluster. Aldebaran is one of many stars whose name begins with the Arabic letters Al-, which means 'the' in English. Some of these star names were given by Arabs living in the Middle East long before the rise of Islam, while others are translations of ancient Greek language descriptions, many from Ptolemy's Almagest. The name Al-de-baran is Arabic for 'the foremost' or 'the leading star' because it 'leads' Pleiades, the other distinctive open cluster in Taurus. Aldebaran's reddish colour is easy to see with the naked eye. Its colour is evidence that it

has burnt up its hydrogen resources and is in the early stages of dying. It has a magnitude of 0.9 and is 65 light years away. This is a much closer distance than the other stars in Hyades – it just seems to be part of the group when viewed from Earth.

## LAST MONTH'S ACTIVITIES

**Monthly centre meeting** The annual Christmas party took place on 10 December at the Catholic Church Hall. Jenny Morris reports: "The members and partners who attended the party found the tables decorated with crackers, tinsel and candles, in mostly red and green colours. While sipping the drinks they had brought with them they feasted on the wonderfully tasty finger food catered, again, by CanD's Kitchen. This included yummy desserts which provided a sugar boost as the teams tackled the famous quiz. Final scores were close, but one team accumulated more points that then others, and its members each received a small chocolaty prize. Unfortunately, the refusal of the computer and the projector to communicate with each other meant that we were unable to watch the few short videos which had been planned. However, the unfailing sounds of chatter and laughter showed that this did not dampen people's spirits. Many hands made light work of clearing up, before Everyman left after another enjoyable end-of-year party".

### Interest groups

**Cosmology** At the meeting on 3 December, Pierre Hugo presented the fifth session in the current series on 'Natural philosophy: science for non-scientists'. The topic was special relativity, specifically on how Einstein's theory fits into alternative conceptions of the nature of space.

**Astro-photography** No meeting was held in December.

### Other activities

**Educational outreach**

**Hawston Secondary School Space Cadets** No meetings took place during December.

**Lukhanyo Youth Club** No activities took place during December.

**Stargazing** No event took place during December.

**Whale Talk article** An article by Jenny Morris titled 'The far side of the Moon' was published in the December 2018/January 2019 issue of the magazine.

## THIS MONTH'S ACTIVITIES

Monthly centre meeting This month's meeting, will take place on **Monday 21 January** at the **Catholic Hall** starting **19.00**. Dr Amanda Sickafoose will be talking on 'Recent results from the outer Solar System'. Amanda is a long-standing friend and honorary member of the HAC. An outstanding presenter, who has given several fascinating presentations in Hermanus in the past, Amanda is Head of Instrumentation at the SAAO in Cape Town and an Affiliate of the Department of Earth, Atmospheric and planetary Science at Massachusetts Institute of Technology (MIT) in the USA.

She states the following about her talk: "A wealth of bodies has been observed in the outer part of our Solar System, including centaurs, dwarf planets, Kuiper Belt objects, Scattered Disc objects, and comets. The distance, combined with relatively small sizes, makes these bodies difficult to study from Earth. Pluto is the best-studied, as the largest, the first discovered, and the only outer Solar-System object to have been visited by a spacecraft. This talk will present the latest observations of bodies in the outer Solar System (specifically Pluto, Chiron, and Orcus) using the technique of stellar occultations,

and it will include any new information that is available from the New Horizons spacecraft's 01 January 2019 flyby of the distant object Ultima Thule."

## 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 is on **Monday 4 February** at the **Catholic Hall**, starting at **19.00.**

There is an entrance fee of R10 per person for members, R25 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. There is no meeting in December. The next meeting will take place on **14 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** Developmental work on this will resume soon.

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

## Other activities

**Stargazing** No event is planned for January. The next meeting is scheduled for **Friday 1 February** at **Gearing's Point.** Details will be circulated to members closer to the time.

## FUTURE TRIPS

Planning is underway for an outing this year. Members will be sent details once the arrangements have been made.

## 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**.

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|---|---|
| 21 January | Topic: 'Recent results from the outer solar system'. Presenter: Dr Amanda Sickafoose, SAAO, CT |
| 18 February | AGM |
| 18 March | Topic TBA. Presenter: Case Rijsdijk, President of ASSA |
| 15 April | 'Another one bites the dust'. Presenter. Dr Shazrene Mohaned, SAAO, CT |
| 20 May | 'The upgraded HESS facility'. Presenter, Herbert Pioller, Centre member |
| 24 June | 'Star formation and the gas cycle in galaxies'. Presenter: Dr Moses Mogotsi, SAAO., CT |
| 15 July | 'Near-Earth asteroids: monitoring close approaches and mitigating objects'. Presenter: Dr Nicolaus Ersamus, SAAO, CT |
| 19 August | 'More unusual curvaceous geographical wonders of Earth'. Presenter: Jenny Morris, Centre member |
| 16 September | Topic TBA. Presenter: Pierre de Villiers, Centre chairman |
| 21 October | TBA |

| | |
|---|---|
| 18 November | 'The Cassini family dynasty and their Saturnian legacy'. Presenter: Jenny Morris, centre member |
| 9 December | Xmas party |

## ASTRONOMY EDUCATION CENTRE AND AMPHITHEATRE (AECA)

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

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

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

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

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

## ASTRONOMY NEWS

**Kepler and Gaia team up to confirm 104 new exoplanets** 3 December: The Kepler space telescope might have run out of fuel a few months ago, but astronomers are still using its data to uncover a slew of new worlds.

Artist's impression of K2-187, a star with four newly discovered exoplanets in its orbit. NASA/JPL-Caltech/R. Hurt, T. Pyle (IPAC), UTokyo/J. Livingston

Using stats from ESA's Gaia mission and Kepler's K2 mission, an extension of Kepler's original planet-finding mission, two recent studies have confirmed the existence of a total of 104 new exoplanets. Their characteristics stretch far and wide, including multi-planet systems, rocky terrestrial worlds, and planets that orbit dangerously close to their host stars. These newfound bodies can be used to understand how different types of planets form, and also give next-generation telescopes promising worlds to investigate.

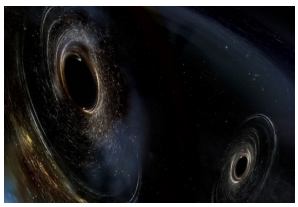
This new batch of exoplanets was discovered in two consecutive waves. In August, researchers from the University of Tokyo announced that they'd confirmed 44 fresh exoplanets by combining data from K2 and Gaia. Before Kepler was retired in late October, the space telescope carried out short observing campaigns and searched for the faint dimming that occurs when a planet orbits its host star. Blending this data with stats from Gaia, a space observatory that is creating a 3D map of one billion nearby stars, the researchers were able to weed out false positives and confirm the new exoplanets. Using

this same method, the University of Tokyo researchers teamed up with the Astrobiology Center of the National Institutes of Natural Sciences to confirm 60 additional exoplanets just three months later.

The research teams were not only able to confirm the existence of 104 new planets, but also learn a bit about them. They found two dozen planets that live in multi-planet systems, with Sun-sized star K2-187 harbouring four alone. There are also 34 planets that probably have rocky compositions and are less than two times the size of Earth, but are probably uninhabitable due to thin or non-existent atmospheres. Most intriguingly, the data shows that seven of these new planets, including one orbiting K2-187, have ultra-short orbital periods - planets so close to their host stars that they circle them in less than 24 hrs. Current formation theory suggests that planets form much farther out in a star's orbit, leaving astronomers questioning how these close-knit systems even exist.

There is still plenty of K2 data to sift through, and the continued discovery of these peculiar planets will help shed light on their formations and evolution. Better yet, a new space telescope is already on the hunt for them. "Although the Kepler Space Telescope has been officially retired by NASA, its successor space telescope, called TESS, has already started collecting data. In just the first month of operations, TESS has already found many new exoplanets, and it will continue to discover many more." said John Livingston of the University of Tokyo. By: Amber Jorgenson

**Four new gravitational wave detections announced, including the most massive yet** 4 December: Scientists have announced the detection of four new gravitational-wave events, bringing the total to 11. With the first captured by the Laser Interferometer Gravitational-Wave Observatory (LIGO) detectors in 2015, the new observations of ripples in the fabric of space-time are quickly adding up and helping researchers to better understand powerful and distant cosmic phenomena like black holes and neutron stars.


Artist's image of 2 merging black holes. LIGO/Caltech/MIT?Sonoma State (AuroreSimonnet)

The US-based LIGO and the European-based Virgo detectors have now detected gravitational waves from a total of 10 stellar-mass binary black hole mergers and one merger of neutron stars, which are the collapsed cores of giant stars. The highlight of the new detections is a black hole merger from about 5 billion years ago that is the most massive and distant gravitational-wave source scientists have ever seen. This merger created a black hole 80 times more massive than the Sun and released an amount of gravitational energy equivalent to 5 solar masses when it occurred.

"Gravitational waves give us unprecedented insight into the population and properties of black holes. We now have a sharper picture of both how frequently stellar mass binary black holes merge and what their masses are. These measurements will further enable us to understand how the most massive stars of our universe are born, live, and die," said Northwestern University's Chris Pankow, who co-chairs the LIGO Scientific and Virgo Collaboration'sCompact Binary Coalescence Rates and Populations subgroup. Thanks to

these new detections, scientists have enough data to infer that nearly all stellar-mass black holes weigh less than 45 times the mass of the Sun. This work also shows how it is possible that more binary black hole mergers occurred earlier in the universe.

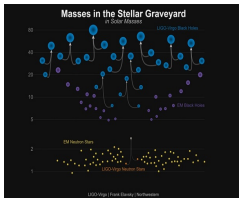
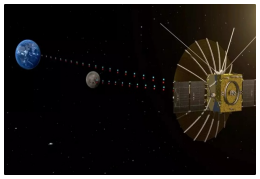


Chart showing the masses of neutron stars (orange) and black holes (blue) detected so far using gravitational waves, versus other types of detections (yellow and purple). LIGO-Virgo, Frank Elavsky, Northwestern

While these detections reveal information about black holes, they also open doors to future research, Pankow explained. With these 11 new events, researchers now have a wealth of new data and opportunities to explore gravitational waves and the events that create them. In the past, our current understanding of black holes was supported by observations with X-rays, optical light, and radio waves. These methods have contributed immensely to astronomy and astrophysics. However, Pankow added, gravitational waves allow us to study and understand binary black holes in a way that cannot be done with other measures. "That's allowed for testing our understanding of what gravity really means," Pankow said, adding that the researchers could also use these detections to better understand how stars evolve and die. By: Chelsea Gohd

**China prepares to head for the far side of the Moon** 6 December: On 8 December at about 02.30 local time, China's robotic Chang'e-4 mission will launch on a Long March 3B rocket, headed for the lunar surface.


Visualisation of Queqiao Chang'e-4 lunar satellite Chinese Academy of Sciences

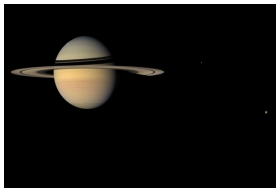
After launching, the spacecraft will spend 27 days travelling to the Moon. Upon arrival at our rocky satellite, an accompanying lander, which doubles as a rover, will descend towards the surface. The craft will touch down in the Von Kármán Crater in the South Pole-Aitken (SPA) basin on the far side of the Moon. In anticipation of the launch, China sent their Queqiao relay satellite into space this past May. This satellite is positioned at the L2 Lagrangian point, 1.6 million km from Earth. Lagrangian points are positions in space where a small object (the satellite, in this case) is gravitationally balanced between two large objects (the Moon and the Earth, in this case) and will remain in place relative to them. Here, the satellite will be able to constantly transmit communications between mission controllers on Earth and the lander-rover on the lunar surface.

This mission, besides being a major first for the China National Space Administration, aims to explore and study both the surface and sub-surface of the lunar region. The mission will include a low-frequency radio-astronomical study of the lunar surface, a shallow exploration beneath the surface, and a study of the topographical and mineralogical composition of the SPA basin. The radio frequency instrument is of special significance because of its location. The lander's home base always faces away from Earth, so a

detector there will not likely pick up human-made radio frequencies and 'noise' from auroras on Earth which could affect data.

The lander-rover will also use its Lunar Penetrating Radar (LPR), one of the eight scientific payloads on board, to sample the lunar surface and what lies directly beneath. In this study, the instrument will examine the thickness and structure of the regolith, or lunar soil, in the region around the landing site. Additionally, according to a story by Xinhua, China's state-run news agency, the mission will also include a biological investigation consisting of a tin full of seeds. This tin will contain water, a nutrient solution, air, a small camera, a data transmission system, and potato and arabidopsis seeds (arabidopsis is a small flowering plant related to mustard and cabbage). Researchers hope to see whether these seeds blossom and grow on the moon. By: Chelsea Gohd

**The Saturn system has water just like Earth's ... except for Phoebe** 6 December: Although we were not here to observe the birth of our own solar system, astronomers have developed a relatively informed picture of how it likely happened, based on observations of our present-day home and the infant planets forming around other stars. However, every so often, something throws a wrench in our theories, and that might have just happened -researchers have discovered interesting new properties of Saturn and its moons that contradict our current models for how the solar system formed.


Saturn and several of its moons appear in this image by Cassini in 2007. NASA/JPL/Space Science Institute

Researchers from the Planetary Science Institute, the University of Arizona, NASA Ames Research Center, and the US Geological survey have reported their measurements of isotope ratios in the Saturn system. Isotopes are atoms of a single element with the same number of protons and electrons, but differing numbers of neutrons. Studying the abundance of certain isotopes helps astronomers piece together an object's history. Some isotopes were more or less common, particularly in certain areas of the solar nebula as it formed planets; others are more likely to stick around or appear after processes such as heating or evaporation. The researchers found that, based on spectroscopic observations of the Saturn system from Cassini, the water in Saturn's rings and moons is surprisingly like the water on Earth - an unexpected result, given their disparate locations. Even stranger, the water on Saturn's moon Phoebe (and only Phoebe) is unlike the rest of the water in the Saturn system, suggesting it formed even farther out in the solar nebula, rather than in place around the ringed planet.

To make these discoveries, the team developed a new way to measure isotope abundances in the readings taken by Cassini's Visual and Infrared Mapping Spectrometer (VIMS). In particular, they studied the ratio of deuterium to hydrogen (D/H) in the water in the Saturn system. Deuterium is an isotope of hydrogen with one proton and one neutron in its nucleus; $D_2O$, which is water that contains deuterium instead of hydrogen, is commonly known as heavy water because of the added mass from the extra neutrons. Each spectrum taken by VIMS breaks the light reflected from the surface of Saturn, its rings, or its moons into its constituent parts to identify the fingerprints of the elements

contained within them. Based on comparison of laboratory spectra with the VIMS results, the team discovered the bulk of the Saturn system's water, including the water in the planet's rings and on its moons (except Phoebe), has a D/H ratio similar to terrestrial water. However, our current models for the formation of the solar system state that the D/H ratio farther out in the solar system should be higher than closer in; if Earth formed close to the Sun and Saturn far from it, why is their water so similar?

According to the team, the similarities indicate that the same type of water might have been found in the inner and outer solar system during its formation, which would require us to change our current models. "The terrestrial-like D/H of Saturn's rings and satellites may indicate a similar water source for the inner and outer solar system, or at least a change in models where the D/H varies less from inner to outer solar system, less than a factor of two from Earth to Saturn," the researchers state. On Phoebe, the D/H ratio "is the highest value yet measured in the solar system, implying an origin in the cold outer Solar System far beyond Saturn," said Roger Clark of the Planetary Science Institute. In other words, Phoebe likely formed elsewhere, much farther from the Sun, and later became a part of the Saturn system through gravitational capture. The only other way for Phoebe to have such a high D/H ratio, he said, is for processes to have enhanced its present-day deuterium supply over time. These processes, however, "[require] Phoebe to have present-day characteristics similar to objects that are composed primarily of rock and organics, which is not what we observe."

Too much deuterium is not the only thing that makes Phoebe odd. In addition to measuring the D/H ratio, the researchers were also able to measure a different isotopic ratio - that of carbon-13 (13C) to carbon-12 (12C) - in the carbon dioxide on both Phoebe and Iapetus (the only two worlds with enough carbon dioxide to make the measurement). While Iapetus' 13C/12C ratio closely matches Earth's, Phoebe's ratio is also skewed, showing five times more 13C than the 'normal' 12C. This oddity, too, points toward an origin for the small moon farther out in the solar system, with different processes responsible for the carbon dioxide on the two moons. Also of note is the fact that, although dust from Phoebe is known to coat the leading side of Iapetus, "if there were any CO2 in the Phoebe dust on ejection from Phoebe, it is apparently lost on its way from Phoebe to Iapetus," the researchers stated. By: Alison Kelsman

**NASA releases first data from OSIRIS-REx asteroid mission** 10 December: OSIRIS-RExhas been busy ever since it arrived at the asteroid Bennu on 3 December. The latest updates from NASA reveal that the space rock is porous, blue, and covered in massive boulders. More excitingly, the mission discovered evidence that Bennu's minerals interacted with water at some point in its distant past.

Image of asteroid Bennu, made up of 12 PolyCam images collected 2 by OSIRIS-REx spacecraft from 22 km away. NASA/Goddard?U Arizona

After reaching its target earlier this month, the craft is currently observing the rocky world remotely as scientists decide where to land. Some of the initial data indicate that Bennu's surface contains clay filled with hydrated minerals, indicating that they came into contact with liquid water at some point. The asteroid itself is too small to host any such water on

its surface, which means its larger parent body likely did at one time. The finding could help reveal how Earth got much of its water, as well as provide hope to future asteroid miners. Researchers found the evidence for these hydrated minerals using the spacecraft's two spectrometers: the OSIRIS-REx Visible and Infrared Spectrometer (OVIRS) and the OSIRIS-REx Thermal Emission Spectrometer (OTES). "This is a great surprise," said Amy Simon, Senior Scientist for Planetary Atmospheres Research in the Solar System Exploration Division at the NASA Goddard Space Flight Centre.

The mission team also found that asteroid looks fairly similar to what they had anticipated, based on a 2013 model. New imagery reveals the same large boulders that stood out to them before, though the surface does appear to be more rugged than previously thought. Based on their model, the team expected the largest boulder on the asteroid to be about 10m tall. However, using preliminary calculations from data taken with the OSIRIS-REx Camera Suite (OCAMS), researchers now estimate the largest boulder to be closer to 50m tall and about 55m wide. The team has also found far more boulders covering Bennu's surface than expected, though smoother regions do exist. This is important for the craft's mission to return samples of Bennu to Earth, as its arm is not very strong, and it will need to land in a place where the rocks are small enough to pick up easily.

The results also reveal that the asteroid has a density just under 1,200 kg/m3. Since the average asteroid has a density around 3,000 kg/m3, this makes Bennu much less dense than the average. This likely means that Bennu is porous, filled with holes and caves like a sponge. The team also found that the asteroid's surface is littered with both shiny and non-reflective rocks, something the team hopes to further examine in the future. They also confirmed Bennu's color: The asteroid is blue (ish), they say. On 31 December, OSIRIS-REx will enter into orbit around the asteroid. This will make Bennu the smallest object ever orbited by a spacecraft. The craft will remain in orbit until February 2019, when it will embark on a series of flybys to survey the asteroid. By: Chelsea Gohd

**After more than 40 years, Voyager 2 has gone interstellar** 11 December: After launching in 1977, NASA's trailblazing spacecraft Voyager 2 has finally escaped the heliosphere, the Sun's protective bubble of charged particles. It follows in the path of its sibling, Voyager 1, which crossed into interstellar space in 2012.

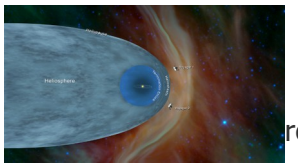


Illustration showing where NASA's Voyager 1 and Voyager 2 probes are relative to one another. NASA/JPL-Caltech

The Sun's solar wind makes up the heliosphere, which surrounds all the planets in our solar system. The boundary where the hot solar winds of the heliosphere end and give way to the cold interstellar medium is known as the heliopause, and it is also the border of interstellar space. On 5 November 2018, instruments aboard NASA's Voyager 2 spacecraft sent back data indicating the craft had crossed the heliopause. The craft is now travelling and collecting data in interstellar space more than 17 billion km from Earth.

Ed Stone, project scientist for the unmanned Voyager missions since 1972, described the three pieces of evidence that led the team to this conclusion. Firstly, there are intense galactic cosmic rays that permeate interstellar space. Some of these rays get into the heliosphere, but the team expected that spacecraft would detect a slow increase in cosmic rays as it neared the heliopause, hen a sudden increase when it crossed the boundary. On

5 November, the craft detected just such a sudden and extreme increase in cosmic rays. Secondly, the team expected the craft to detect dramatically fewer of the charged particles that make up the heliosphere once the it crossed the heliopause. Also on 5 November, Voyager 2 suddenly registered fewer of these particles. Thirdly, the team expected the craft to detect a sudden jump in magnetic field intensity as it crossed over out of the heliosphere, which it also saw.

While these findings show that the spacecraft has crossed this line from the heliosphere into interstellar space, it does not mean Voyager 2 has left the solar system. While the heliosphere does encompass the Sun and all of the planets in our solar system, there are still comets and other icy bodies in the Oort Cloud, which lies outside the heliosphere, that are part of our solar system. So while the craft has gone interstellar, it cannot be said that it has completely left the solar system. (Neither has Voyager 1, which left the heliosphere several years ago). Voyager 2 will continue to study the cosmos from the other side of the heliopause, as Voyager 1 has been since 2012. Suzanne Dodd, NASA Jet Propulsion Laboratory's Director for the Interplanetary Network Directorate, estimated that the craft will continue to transmit data back to us for perhaps another decade. By: Chelsea Gohd

**Juno's mission to Jupiter hits its halfway point: Here is what has been learned so far** 14 December: NASA's solar-powered Juno spacecraft is about to fly past Jupiter yet again to gather more data on the gas giant. On 21 December, at 11:49:48 am EST, Juno will pass just 5,053 km from Jupiter's cloud tops at 206,803 kph per hour. This will be the spacecraft's 16$^{th}$ science pass of the planet, meaning that Juno's prime mission will be halfway complete. With this 16$^{th}$ flyby, the Juno mission will have observed the entire planet, Jack Connerney, the mission's deputy principal investigator, said. Moving forward after this milestone, the craft will provide observations and measurements about the planet in greater clarity and detail. "Over the second half of our prime mission - science flybys 17 to 32 - we will split the difference, flying exactly halfway between each previous orbit. This will provide coverage of the planet every 11.25° ongitude, providing a more detailed picture of what makes the whole of Jupiter tick," Connerney said.

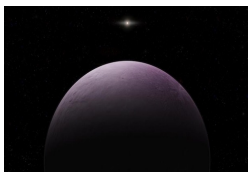
Juno has been in an elliptical orbit which takes it around Jupiter every 53 days. The craft initially arrived at the planet on 4 July 2016, and has been gathering scientific data since August of that same year. In the flybys that Juno has so far completed, the craft has used the scientific instruments on board to study the planet beneath its swirling clouds. Juno continues to explore Jupiter's atmosphere, magnetosphere, and interior structure, and collect data about its auroras to better understand how the planet formed and evolved.

Juno has, sao far,made a number of groundbreaking discoveries about this gas giant. Among other findings, the spacecraft found that Jupiter's jet streams are like nothing we see on Earth, and help to give the planet its distinctive stripes. The craft has also studied the water content of the planet using a microwave radiometer to peer into the planet's atmosphere. By measuring how much water is held there, researchers can better understand how much oxygen is on the planet, which further informs studies about how the planet formed. Also, the JunoCam imager makes Jupiter's beauty accessible to the general public by capturing the gas giant in all its glory, and time-lapse sequences taken with the imager have allowed researchers to better study dynamic activity on the planet.


Infrared 3-D image of Jupiter's north pole from data collected by the Jovian Infrared Auroral Mapper aboard Juno spacecraft.NASA/JPL-Caltech/SwRI/ASI/INAF/JIRAM

Other instruments aboard the craft have also given researchers a much better glimpse beneath the planet's surface. Brand new images of a tangled magnetic field driven by a powerful dynamo and a host of dancing cyclones are allowing researchers to build towards a more comprehensive model of the gas giant's interior. "We have already rewritten the textbooks on how Jupiter's atmosphere works, and on the complexity and asymmetry of its magnetic field. The second half should provide the detail that we can use to refine our understanding of the depth of Jupiter's zonal winds, the generation of its magnetic field and the structure and evolution of its interior," Scott Bolton, principal investigator of Juno, said about the future of the mission. After Juno completes its mission, the spacecraft will leave Jupiter's orbit in a controlled manner and disintegrate into the planet's atmosphere. It is possible, however, that certain instruments may fail before this point because of the high levels of radiation emanating from the planet's magnetosphere. By: Chelsea Gohd

**Astronomers have found the most distant dwarf planet in the solar system to date** 18 December: A team of astronomers has discovered the most 'far out'object ever observed in our solar system. The object, a pink dwarf planet called 2018 VG18 and nicknamed 'Farout', lies more than 100 times farther from the Sun than Earth.


Artist's visualisation of the newly discovered dwarf planet 2018 VG18, or Farout, with our sun in the background. Roberto Molar Candanosa/Carnegie Institution for Science

This discovery, made by Carnegie's Scott S. Sheppard, the University of Hawaii's David Tholen and Northern Arizona University's Chad Trujillo, was formally announced by the International astronomical Union's Minor Planet Centre. Farout is about 120 AU away - 1 AU is the distance between the Earth and the Sun - making it the first object discovered at over 100 AU. Farout is significantly farther than the now second most-distant object Eris, which is at about 96 AU. The pink dwarf planet is more than three-and-a-half times more distant than the famous, blue dwarf planet Pluto.

The team discovered Farout using the Japanese Subaru 8-meter telescope located in Hawaii. The first discovery images were taken 10 November 2018. The object was observed a second time earlier this month at the Magellan telescope at Carnegie's Las Campanas Observatory in Chile. These secondary observations allowed the team to follow the object's path across the sky and determine its brightness and color. From these observations, the team found that dwarf planet is fairly sizable, about 500 km in diameter or roughly 1/3 the size of Pluto, Sheppard said. The dwarf planet also has a pinkish hue likely caused by the object being rich in ice.

While a significant discovery on its own, finding Farout may also support the search for 'Planet X' - a theoretical planet whose existence was first proposed by this same research team after discovering another distant solar system object. Farout and other distant

bodies seem to move in a strange harmony best explained by the existence of an as-yet-unseen massive planet beyond Neptune in the Solar System It will be at least a year, and likely more, before researchers understand Farout's orbit enough to say if it actually provides evidence for Planet X. While the team's main focus is looking for Planet X, they continue to keep their eyes peeled for other objects in the same general vicinity. Farout is one such unexpected prize from the search. Another, 'The Gonlin' was found earlier this year by the same team. By: Chelsea Gohd

**Astronomers find a 'fossil cloud' uncontaminated since the Big Bang** 20 December: Astronomers have discovered an ancient remnant of the Big Bang with some of the world's most powerful telescopes. This scrap of pure material from the universe's beginning could help researchers to better understand how and why different types of stars and galaxies formed in the early universe. A group of astronomers, led by Fred Robert and Michael Murphy of the Swinburne University of Technology in Australia used telescopes at the W M Keck Obervatory in Hawaii to find a cloud of gas left over from the Big Bang lurking far out in the universe. The telescope also found a quasar - an ultra-bright active galactic nucleus emitting lots of energy - lurking behind the cloud. This cloud is a remarkable find because has changed remarkably little since its creation. "Everywhere we look, the gas in the universe is polluted by waste heavy elements from exploding stars. But, this particular cloud seems pristine, unpolluted by stars even 1.5 billion years after the Big Bang," Rober said. "If it has any heavy elements at all, it must be less than 1/10,000th of the proportion we see in our Sun. This is extremely low; the most compelling explanation is that it's a true relic of the Big Bang," he added. Because the quasar behind the ancient cloud is so bright, it illuminates the material in it. This illumination allowed the researchers to see the spectral shadows of the hydrogen in the gas cloud, and because it has not been contaminated, it is a look at what the cloud looked like billions of years ago.

This is not the first cloud remnant from the Big Bang ever discovered. In 2011, researchers discovered two other 'fossil clouds'. "The first two were serendipitous discoveries, and we thought they were the tip of the iceberg. But no one has discovered anything similar – they are clearly very rare and difficult to see. It's fantastic to finally discover one systematically," astronomer John O'Meara, who discovered the first two fossil clouds along with colleagues, added. "It's now possible to survey for these fossil relics of the Big Bang," Murphy continued. Studying these ancient clouds gives scientists a better idea of what the universe was like at the time of the Big Bang - potentially explaining how and why some gases in the early universe became certain stars and galaxies and others did not. By: Chelsea Gohd

**New Hubble images let astronomers 'see' dark matter** 27 December: Two astronomers have devised a method that lets them 'see' dark matter with the light from rogue stars. They have shown how images of faint starlight taken with the Hubble Space Telescope can be used to map dark matter's distribution in galaxy clusters. The novel technique could ultimately help explore the nature of dark matter. Dark matter remains one of the great mysteries of modern science. A theoretical form of matter, dark matter is thought to make up about 85 percent of all matter in the universe. Because dark matter does not absorb, reflect or emit light, it is very hard to spot. In fact, it has never been directly observed and some even question whether or not dark matter actually exists. This new method, however, lets astronomers detect dark matter in galaxy clusters using what's called intracluster light. Intracluster light is faint starlight that's created by interactions

between galaxies. When galaxies interact, their respective stars can be ripped apart from them, left to float freely throughout the galaxy cluster. "These stars have an identical distribution to the dark matter, as far as our current technology allows us to study," Mireia Montes of the University of New South Wales said. Because the intracluster light aligns with the dark matter in these clusters, it allows astronomers to see how the dark matter is distributed.


Intracluster light (blue) in the galaxy cluster Abell S1063.Credit: NASA, ESA, and M. Montes (University of New South Wales, Sydney, Australia)

In this study, the astronomers used data from the Frontier Fields Hubble Space Telescope program. "We have found a way to 'see' dark matter. We have found that very faint light in galaxy clusters, the intracluster light, maps how dark matter is distributed," Montes said about this new method. Other efforts to map the distribution of dark matter use gravitational lensing - a technique that uses the light bent by matter in between a light source and the observer. While gravitational lensing requires accurate lensing and time-intensive spectroscopy, this new technique only requires deep-space imaging. Because of this, the astronomers who devised the new technique say it will be a more effective tool for mapping and studying galaxy clusters.

Aside from providing an effective method with which astronomers can map dark matter, this new research also offers opportunities to better explore the nature of dark matter itself. For example, dark matter appears to interact with regular matter only gravitationally. However if researchers using this method find that dark matter actually distributes differently from the floating starlight, it could mean that dark matter is self-interacting. This would significantly change our current understanding of dark matter, what it might be, and how it behaves. By: Chelsea Gohd

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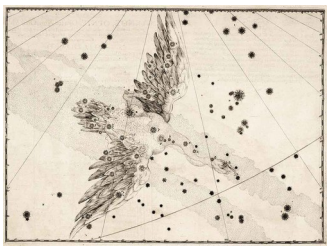
DID YOU KNOW?

**Astronomical catalogues Part 3: Johann Bayer's catalogue and Bayer letters: using Greek to label stars**


Johann Bayer

Uranometri


Cygnus constellation

At the same time as Brahe was working on his star catalogue, the German Johann Bayer (1572 – 1625) was working on his star atlas. Although a practising lawyer, he also had an active interest in mathematics and astronomy. Ptolemy's very old catalogue, with its 48 constellations, was still widely in use in 16th century astronomy. It was very dated and also

demonstrated no consistent use of a generic labelling system for the stars within each constellation.

More stars had been discovered during the 16th century. Also, Dutch navigators had identified twelve newly discovered southern constellations. Both these and the new stellar observations needed to be added to Ptolemy's original list. Bayer took on the task to compile an updated catalogue. Building on the catalogue compiled by Ptolemy, by adding data from Brahe's expanded and updated early manuscript catalogue and possibly also Piccolomini's 1540 star atlas, and adding observations from the southern hemisphere, he was able to produce the most comprehensive pre-telescopic astronomical catalogue. It was revolutionary in being the first astronomical catalogue to cover the whole sky, This was marked progress in itself, but Bayer's historical significance lies in the innovative systematic, succinct method he used for labelling stars. It was not a perfect system, but the so-called Bayer letters are his lasting legacy.

His star atlas *Uranometria* Omnium Asterismerum (Measuring all the stars in the heavens) was published in 1603. In it, he allocated lower case Greek letters to the main stars in each constellation. For each star, the Greek letter was followed by the genitive (possessive) form of the parent constellation's name. This name was shortened to a 3-character abbreviation eg α CMa for Sirius, the brightest star in Canis Major, β Cen for the second brightest star in Centaurus.

Designations were mostly made in a rough order of apparent brightness, from brightest to dimmest. Logically, in most constellations, the brightest star is designated alpha, the next brightest beta etc, although this was not a specific intent. In Bayer's day, magnitude was very difficult to measure accurately. The six-level system of brightest in 1st order to dimmest at 6th meant that each magnitude level could contain several stars. Bayer listed all first magnitude stars first, followed by those of second magnitude etc. Within each class, however, he did not attempt to arrange the stars by their comparative brightness to others in the same group. Thus, the alpha star in a constellation may not be the brightest.

This has produced some labelling oddities. For example, in Orion, Betelgeuse is listed alpha compared to Rigel's beta, although the latter is brighter. Betelgeuse got priority because it is located further north than Rigel. These anomalies mean that, of the current 88 constellations, the 'alphas' in at least 30 are not the brightest in that constellation. Of those 30, four do not have an 'alpha' at all including Vela, Puppis. Bayer also sometimes ordered stars by their right ascension order rather than their brightness. For example, in Gemini, Pollux is brighter than Castor, but Castor rises first and is labelled 'alpha'. Although later astronomers tended to follow the magnitude system, it was not predominant. If a newly discovered star was brighter than the existing Bayer designation, the latter was not changed, and the new star was given a lower order latter.

If a constellation contained more than 24 stars, the numbers available in the Greek alphabet, he then moved on to the Latin upper case alphabet eg A. A number of stars in Southern Hemisphere constellations have upper case designations eg B Centauri, G Scorpii. As more and more stars were identified over time, the system has been extended by astronomers, using Roman numerals and then these plus alphabetic letters. Although few Bayerian upper case Latin letter designations remain in use, the lower case Greek letter system is embedded in astronomy The Bayer system is still in use and has been extended to cover around 1,300 stars.

*Uranometria* contained 1,564 stars, of which around 1,200 were taken from Brahe's catalogue. These were positioned across 49 constellation maps, Ptolemy's original 48 and the final page containing the 12 new southern constellations. Due to limited observation of Southern Hemisphere stars, the latter contained very few designated stars. Later, astronomers like de Lacaille added further southern constellations to those covered by Bayer. Bayer was careful to cross-index the labels for his stars with the names of those in used by Ptolemy, Brahe and others in order to facilitate their identification.

A devout Protestant, Bayer was uncomfortable with the traditional heathen names given to the constellations. In *Uranometria,* he proposed alternative Biblical names, New Testament figures for Northern Hemisphere constellations and Old Testament figures for those in the south. This approach did not catch on, unlike his innovative lettering system.

Sources: Ridpath, I (Ed) (2012) Oxford dictionary of astronomy 2nd ed rev, www.astronomy.stackexchange.com, www.britannica.com, www.en.wikipeda.org, www.encyclopedia.com

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