"The Southern Cross"

HERMANUS ASTRONOMY CENTRE NEWSLETTER

DECEMBER 2018

Monthly meeting This month's meeting is the annual Christmas party. It will place on **Monday 10 December** at the **Catholic Church Hall** starting at **18.30** for **19.00**. Bookings closed on 30 November.

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?

Geminids meteor shower Meteor showers are named for the constellations located in the area of sky from which they radiate. Thus, the Geminids can be seen in Gemini. These showers occur when Earth passes through a trail of debris orbiting the Sun. Most of these 'meteor streams' originate from periodic comets (comets which have been observed orbiting on a regular cycle). The showers occur annually as Earth moves through its orbit of the Sun and crosses the place where dust has been released by the passing comet. Some showers are more visible than others, but even these vary in their intensity. The Geminids are one of the three most active annual meteor showers, along with the Perseids and Taurids. Unusually, their origin appears to be not from a comet, but from the asteroid Phaethon, one of the Earth-crossing asteroids of the Apollo Group. Discovered

only in 1983, its orbit is very similar to that of the Geminid shower and no candidate comet has been identified. The Geminids reach a maximum on 14 December, but activity may be seen from 4th -16th, low towards the north-east in the vicinity of Castor (Alpha Geminorum) the lower of the two prominent stars which form the Gemini 'twins'. The showers will be strongest from 23.30 – 03.00.

LAST MONTH'S ACTIVITIES

Monthly centre meeting Johan Retief reports: "At the meeting on 19 November, Dr Jenny Morris delivered a fascinating presentation on the geological history of Table and the role the mountain has played in astronomy. Going back about 550 million years ago, Jenny told us about how the mountain formed in its various layers with the topmost layer consisting of 'Table Mountain sandstone' and that the mountain 'sits' on a layer of 'Cape granite' and 'Malmesbury shale'. The Table Mountain sandstone is highly resistant to weathering and erosion and protects the mountain to maintain its current shape.

In 1687, Sir Isaac Newton advanced the hypothesis that the Earth has an oblate shape (flattening at the poles). To prove this hypothesis various measurements of the arc of the meridian (the distance along the meridian connecting two points of known latitude was measured in the northern hemisphere. To prove or disprove Newton's hypothesis the same measurement should be done in the southern hemisphere. The Abbé Nicolas-Louis De La Caille was an ardent astronomer and mathematician in France in the 18th century. In 1751, La Caille arrived in Cape Town with the set task to observe and record as many stars as possible; this he did from his observatory in Cape Town and within the first year he observed nearly 10,000 stars and created 14 new constellations, one of them *Mons Mensa* (now known as *Mensa* only), named for Table Mountain. During his second year the Cape, he concentrated on measuring the arc of the Meridian at the Cape. His result was less than satisfactory as it indicated that the radius of the Earth in the southern hemisphere is less than the northern hemisphere.

In 1820, Col George Everest, then involved in the trigonometric survey of the Indian sub-continent, visited South Africa. Here, the Rev Fearon Fallows, first Astronomer at the Royal Observatory in Cape Town they discussed La Caille's result. Everest pointed out that the gravitational attraction of Table Mountain (at the southern end of the arc) and Piketberg (at the northern end of the arc) may have moved the plumb-line of the zenith sector sufficiently to produce an error La Caille's measurement. This led to a second attempt to measure the arc of the meridian in the 19th century by Sir Thomas Maclear, a task that was successfully completed in 1847 proving that Sir Isaac's hypothesis was correct. Maclear's Beacon on Table Mountain is named for Sir Thomas.

Jenny then went on to acquaint us various other table shaped mountains (like in the Karoo and various other regions in South Africa, including Table Mountain in the Cederberg. She also told us about Table Mountain and the Table Mountain Observatory, both in California. The latter is the site of the International Astronomical Union's Minor Planet Centre from where the database of minor planets/asteroids is maintained."

Interest groups

Cosmology At the meeting on 5 November, Pierre Hugo presented the fourth part in the current series on 'Natural philosophy: science for non-scientists'. The topic was again particle physics, focussing on novel perspectives on de Broglie pilot waves, projectile motion and wave-particle duality.

Astro-photography Those who attended the meeting on 12 November discussed image processing hardware and software.

Other activities

Educational outreach On 3 November, three committee members accompanied learners from the Lukhanyo (15) and Hawston (7) astronomy youth groups on a day trip to Cape Town. During a busy and exciting day they visited the Science Centre, Noon gun, the Planetarium and SAAO.
Hawston Secondary School Space Cadets Meetings for the year stopped at the end of October because of the start of exams.
Lukhanyo Youth Club Work continues to erect an analemmatic sundial at this, and other schools in the Overstrand.

Stargazing Despite the presence of high cloud and some wind, those who attended the event on 3 November were able to observe several objects, including Jupiter, Saturn, Mars, and the Omega Centauri and Tucana 47 globular clusters.

THIS MONTH'S ACTIVITIES

Monthly centre meeting

This month's meeting, will take place on **Monday 10 December** at the **Catholic Hall** starting at **18.30 for 19.00** for those who have booked to attend the annual Christmas party.

Interest group meetings

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

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 **15 January**.

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

Hermanus Youth Robotic Telescope Interest Group Developmental work on this will resume in 2019.

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

Other activities

Stargazing No event is planned for December.

FUTURE TRIPS

No events are being planned, at present.

2018 MONTHLY MEETINGS

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

10 December	Xmas party

2018 MONTHLY MEETINGS – porvisional list

21 January	Topic TBA. 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:

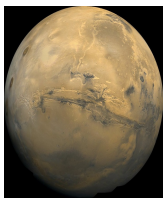
Account name – Hermanus Astronomy Centre
Account number – 185 562 531
Branch code – 051001

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

ASTRONOMY NEWS

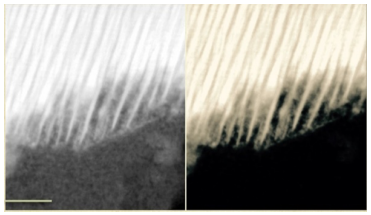
Organic carbon on Mars come from natural 'batteries' 2 November: For years, astronomers have wondered where the Red Planet got its organic carbon compounds, which are associated with life as we know it on Earth. Organic carbon often comes from biological sources on Earth, but researchers have been working to figure out how they are

created on Mars. Now, a new analysis of Martian meteorites indicates that the organic carbon on Mars may come from naturally-occurring 'batteries'.


Mosaic image of Mars from images by 1970s Viking Orbiters, USGS, NASA

By analysing three meteorites that fell to Earth from Mars, a research team led by Andrew Steele of the Carnegie Institution for Science found that the meteorites hold organic carbon similar to the kind detected on Mars by NASA's Curiosity rover. That allowed Steele and his team to study and reveal how organic carbon compounds are synthesized on Mars. The team found that the compounds were likely created by the electrochemical corrosion of Martian minerals by salty liquid brine. This process works like a natural, corrosion-powered 'battery', providing energy for the reactions that create the compounds, Steele said.

This work stems from research in 2012, where Steele and his team confirmed that the organic carbon in these meteorites really did come from Mars and not any Earthly contamination. They also found that the carbon did not come from a biological source. This new work aimed to figure out where the carbon came from, if it was not created by life. "Revealing the processes by which organic carbon compounds form on Mars has been a matter of tremendous interest for understanding its potential for habitability," Steele said. "The reactions that are taking place are probably very similar to what happened on early Earth," he adds. In fact, anywhere igneous rock is surrounded by salty brines, like in Europa's and Enceladus' subsurface oceans, this process could occur.


A high-resolution Transmission Electron Micrograph (scale 50nm) of a grain from a Martian meteorite. Credit: Andrew Steele

To reach this conclusion, the research team used a high-resolution electron microscope and a spectrometer to take images of samples from the three meteorites. As can be seen in the image above, the team was able to pick out lines from the carbon layers. This type of texture, or layering, happens when the minerals in Martian rock interact with salty liquid brine, creating a corrosive reaction. "Mars could be showing us a key clue as to how life started on this planet," Steele said, adding that in the search for life, even a negative answer could inform our understanding of how life forms. By: Chelsea Gohd

OSIRIS-REx gets its first close-up photos of asteroid Bennu 2 November: At long last, NASA's Origins, Spectral Interpretation, Resource Identification, Security, Regolith Explorer (OSIRIS-REx) spacecraft has delivered an up close and personal view of asteroid Bennu. The mission has spent more than two years travelling toward the carbon0rich asteroid, and is now within just 330 km of its target.


OSIRIS-REx images asteroid Bennu from just 330 km away.
NASA/Goddard/University of Arizona

This composite image was created from eight shots taken by the craft's PolyCam camera. After the craft transmitted its data back to Earth, researchers used a super-resolution algorithm to combine the photos and give us a never-before-seen look at the asteroid's rocky terrain. "The first images that capture the entire asteroid are used for an important number of calibrations that are fundamental to correctly interpret the results obtained from higher resolution images using different colour filters," said Juan Luis Rizos García, a researcher at the Instituto de Astrofísica de Canarias (IAC) and part of OSIRIS-REx's team.

Once the spacecraft arrives at Bennu in December, it will switch to its colour-filter MapCam, which will map the asteroid and document its physical characteristics. The camera will also look for alteration in surface minerals that could have been caused by the presence of liquid water. OSIRIS-REx's obligations go far beyond taking pictures, though. The mission, which embarked on its 1.77 billion km round-trip journey in September 2016, will also search for orbiting satellites, or mini-moons; study the asteroid's spectrum to determine its composition; and ultimately collect samples to bring back to Earth. Scheduled for July 2020, the craft will descend to a preselected landing site and use its Touch-And-Go Sample Acquisition Mechanism (TAGSAM) to contact the surface. In the span of just five seconds, the mission will shoot the surface with nitrogen gas and blast it into pieces small enough to take back to Earth.

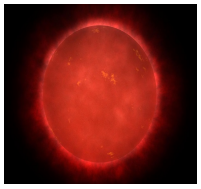
These samples will not only give researchers an untainted look at an asteroid, but they will also allow us to study our solar system's formation and evolution. It is thought that asteroids have more or less remained the same since they first formed in the early days of our solar system, and that they still house the organic molecules, volatiles, and amino acids responsible for creating life on Earth. By probing asteroids, researchers could gain insight into these crucial elements and possibly track how they spread through our ancient solar system. Since previous observations showed that Bennu is rich in carbon, a prominent element in our solar system's earliest asteroids, it makes for a promising, primitive target.

That is not the only reason researchers decided to probe Bennu. Every six years, the asteroid comes within just 300,000 km of Earth - landing it on NASA's list of potentially hazardous asteroids. Although the chances are slim, it is possible that the 500m long body could impact Earth in the late 22nd century. Such an event would be far from catastrophic, but if you have the opportunity, you might as well size up your competition.

OSIRIS-REx's results will come in only slightly behind those from JAXA's Hayabusa2 mission, which arrived at asteroid Ryugu in June and will probe it until 2020. Combined with data from OSIRIS-REx, which will study Bennu until 2021, the time to decode asteroids and the history of our solar system could soon be upon us.

By: Amber Jorgenson

Astronomers spot one of the oldest stars in the entire universe 7 November: One of the oldest stars in the universe is quietly hiding out in the Milky Way some 2,000 light-years from Earth.



Artist's concept of a small red dwarf star is shown above. NASA/Walt Feimer

According to a new study, the tiny, 13.5-billion-year-old red dwarf contains barely any heavy elements at all, suggesting it formed out of a nearly pristine cloud of material leftover from shortly after the Big Bang. Furthermore, because the small star is just one-seventh the mass of the Sun and is made of primordial matter, it is making astronomers reconsider the demographics of the very first stars.

The first stars to form in the universe likely fliched on around 200 million years after the Big Bang. These early stars were forged out of the material that was available to them at the time - mostly hydrogen, some helium, and a touch of lithium. As these stars lived out their lives, they converted their starter elements into progressively heavier elements, which astronomers call 'metals'. Eventually, some of these early stars exploded as supernovae, which spewed their trapped metals out into the cosmos. Then, the next batch of stars formed from the resulting, slightly metal-enhanced clouds. On and on this went, with each successive generation of stars enriching the next with more and more metals.

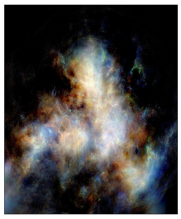
"Our Sun likely descended from thousands of generations of short-lived massive stars that have lived and died since the Big Bang," said Kevin Schlaufman of Johns Hopkins University. "However, what's most interesting about this star is that it had perhaps only one ancestor separating it and the beginnings of everything."

Although finding a star that's been around since shortly after the Big Bang is undoubtedly fascinating, the small stature of the old, metal-poor star (succinctly named 2MASS J18082002-5104378 B) is equally intriguing. In general, astronomers think the universe's first stars were extremely massive, and lived quite short lives. In fact, until the late 1990s, many researchers thought that the early universe could only form massive stars. However, that view has slowly evolved over the years as simulations have become increasingly sophisticated. For example, a Japanese study in 2012 carried out simulations that showed the formation of low-mass stars in the early universe could potentially be triggered by nearby supernova explosions.

Although astronomers are not exactly sure how tiny 2MASS J18082002-5104378 B formed, "this discovery tells us that the very first stars in the universe didn't have to all be massive stars that died long ago," said astrophysicist Andrew Casey of Monash University. "These ancient stars could form from very small amounts of material, which means some of those relics from soon after the Big Bang could still exist today. That gives us a new viewpoint for star formation in the early universe." By: Jake Parks

The Small Magellanic Cloud is running out of gas - fast 13 November: Just as each successive smartphone companies release includes a higher-resolution camera for sharper, more detailed photos, each new instrument astronomers build reveals the universe in

ever-finer detail. In this case, that new instrument is the Commonwealth Scientific and Industrial Research Organisation's (CSIRO) Australian Square Kilometre Array Pathfinder (ASKAP) array, containing 36 radio antennas whose data is combined into a single wide-field image of the sky. Researchers have now used the ASKAP array to image the Small Magellanic Cloud (SMC), one of the Milky Way's small satellite galaxies, in three times more detail than ever before. The new view has allowed them to see that the tiny galaxy is quickly losing hydrogen — and with it, its ability to form new stars.



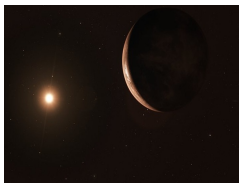
About 200,000 light-years from Earth, the SMC is a dwarf galaxy only about 7,000 light-years in diameter. This radio image shows hydrogen gas in the SMC, Naomi McClure-Griffiths *et al*, CSIRO's ASKAP telescope

The results identify "a powerful outflow of hydrogen gas from the Small Magellanic Cloud," said Naomi McClure-Griffiths of the Research School of Astronomy and Astrophysics at The Australian National University (ANU). The outflow, which astronomers believe may have formed between 25 million and 60 million years ago, stretches at least 6,500 light-years from the galaxy's centre. The team estimates the outflow contains about 107 solar masses of material, which amounts to about 3 percent of the galaxy's total atomic gas. What's more, the SMC is losing gas up to ten times faster than it is currently forming stars. "The implication is the galaxy may eventually stop being able to form new stars if it loses all of its gas," McClure-Griffiths said. In that case, she added, it will "gradually fade away into oblivion. It's sort of a slow death for a galaxy if it loses all of its gas."

The SMC's story is already set to end in tragedy - ultimately, the tiny dwarf will be swallowed up, or 'cannibalized', by the Milky Way, all of its stars, gas, dust, and dark matter ending up as part of our own galaxy, with few traces of the dwarf left behind. Several decades ago, astronomers first observed a 'tail' of gas - mostly hydrogen - trailing the Large and Small Magellanic Clouds, stretching more than 100° on the sky. Called the Magellanic Stream, the tail is believed to have resulted from gravitational interactions between the Milky Way and one or both dwarfs, though the exact cause is still debated and numerous factors likely contribute to its current length and shape. "The result [from this study] is also important because it provides a possible source of gas for the enormous Magellanic Stream that encircles the Milky Way," McClure-Griffiths said.

This study marks the first time the amount of mass loss from a dwarf galaxy has been observationally measured, setting the stage for future studies of the same kind. Measuring the amount of mass flowing from dwarf galaxies is important, as the gas they lose not only affects their internal rate of star formation, but also provides gas to the intergalactic medium between galaxies. Small dwarf galaxies are the most abundant galaxies in the universe; they also have less gravity than their larger cousins, thus losing mass more easily. Understanding how and why dwarf galaxies lose gas through outflows such as this, which could be driven by intense star formation events, will help astronomers better understand how systems of galaxies interact and evolve. By: Alison Klesman

Maybe next time: Barnard's star b is likely uninhabitable 14 November: An international team led by researchers from the Carnegie Institution for Science announced today that they have detected an exoplanet orbiting Barnard's star, the closest single star to Earth at just six light-years away. The astronomers calculate that the new-found world, dubbed Barnard's star b, is about 3.2 times the mass of Earth and orbits its host star once every 233 days. The so-called super-Earth is the second-closest known exoplanet, trailing just behind Proxima Centauri b at a mere 4.2 light-years away, and that could make it an exciting place to look for life. However, unlike Proxima b, which shows promising signs of habitability, Barnard's star b is likely inhospitable to life as we know it.


Artist's image of Barnard's star b and its dim host star. ESO/M. Kornmesser

Barnard's star is a cool, low-mass red dwarf estimated to be at least twice as old as our Sun, with some calculations putting it at 12 billion years old. Consequentially, the dim, ancient star only emits about 0.4 percent of the energy that the Sun does, providing little warmth to its surrounding environment.

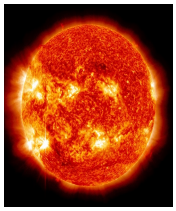
Using ESO's High Accuracy Radial velocity Planet Searcher (HARPS) and Ultraviolet and Visual Echelle Spectrograph (EVES), the research team found that Barnard's star b orbits about 60 percent closer to its host star than Earth does to the Sun. However, despite its snug proximity, the planet still sits beyond the chilly star's 'snow line' - the region where water and other volatiles start turning into ice. At this distance, the planet only receives about two percent of the energy that the Sun gives to Earth, putting its surface temperature at a frigid -170 degrees Celsius.

"The temperature of the star relative to the orbit of the detected planet means that it likely does not have surface liquid water, which is a prime characteristic for deeming a planet even potentially habitable," said Johanna Teske, a NASA Hubble Postdoctoral Fellow at Carnegie. "A planet in the 'habitable' or surface liquid water zone of Barnard's star would have a period between 10 and 40 days, much shorter than the detected planet at 233 days." On top of the planet's icy nature, the actions of its host star could also be a threat to life. It is not uncommon to see flares blasting out of red dwarfs during their younger and middle-aged years, but witnessing one shoot out of an older one is quite rare. Back in 1998, though, astronomers saw a powerful flare erupt from Barnard's star causing its temperature to soar from about 3,100K to at least 8,000K. Such flares likely contain hefty amounts of X-ray radiation, and it is not clear whether Barnard's star b has an atmosphere to protect it from them.

Just because the new world is likely inhospitable does not, however, mean that we cannot use it to better understand the universe. Given its close proximity to Earth, we could potentially use Barnard's star b to learn about other exoplanets that orbit red dwarfs, which are the most common type of star in the Milky Way. "One thing I'm interested in, in terms of other stellar characteristics, is how we can learn about planet interior composition by correlating it to the stellar composition," said Teske. "This work is still in fairly early stages, but there is some indication that some aspects of a small planet's interior composition can be better estimated when the stellar composition is also included in the

model. So, maybe if we can know the compositions of stars, that can help inform our picture of the compositions of their small planets." However, while probing our new neighbour sounds like the obvious next step, it might not be easy, or even possible any time soon. "I think the most useful study would be direct imaging observations of reflected light from the planet, to assess its surface composition and/or whether it has an atmosphere," said Teske. "These would be very challenging observations, though, only possible with next-generation space-based telescopes and instruments. But this would be a great target for those missions." By: Amber Jorgenson

Astronomers find a 'solar twin' 19 November: In a rare discovery, an international team of astronomers has found a star that was likely born in the same stellar nursery as our Sun. After analysing the characteristics of thousands of stars in the Milky Way, the group is confident that they have not only found a solar sibling, but possibly a solar twin.


Composite image of the Sun by ASA's Solar Dynamics Observatory (SDO). NASA/SDO

Named HD186302, the near-identical star is only the second of the Sun's close relatives ever identified. The finding could help researchers understand the environment the Sun and its siblings formed in, and possibly uncover habitable planets within the twin's orbit.

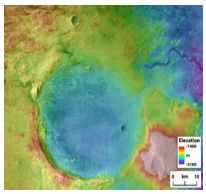
The Sun sits in relative isolation now, but billions of years ago, it was part of a young, crowded neighbourhood. Like all stars, it was born in a massive stellar nursery with thousands of others. However, due to the tidal forces of the Milky Way, the nursery was torn apart, and the stars were scattered about the galaxy. And since stars often travel far from their birthplaces, finding them has been a pretty tough task. However, researchers from the AMBRE project are working hard to uncover the Sun's ancient family. A collaboration between ESO and the Observatoire de la Cote d'Azur, AMBRE uses an array of spectrographs, along with data from ESA's GAIA mission, to identify the ages, chemical abundance and motions of stars in the Milky Way. Thanks to this extensive dataset, researchers from the Instituto de Astrofísica e Ciências do Espaço (AI) in Portugal were able to probe 17,000 different stars.

After combing through the celestial records, the team found a star that has an uncanny resemblance to the Sun. HD186302 is a main sequence star, and it sits about 184 light-years from Earth. The star has roughly the same age, metallicity, chemical abundances and even ratios of carbon isotopes as the Sun. In other words, it is just about as Sun-like as you can get. These undeniable commonalities make it just one of two stellar sibling ever identified, following just behind HD 162826, discovered in 2014.

Astronomers could use these similarities to determine the type of environment that the siblings formed in, helping to paint a picture of their now-defunct stellar nursery and the other family members that were born within it. The discovery also leads researchers to wonder if, like the Sun, HD186302 could house life and habitable planets. "Some theoretical calculations show that there is non-negligible probability that life spread from Earth to other planets or exoplanetary systems, during the period of the late heavy

bombardment. If we are lucky, and our sibling candidate has a planet, and the planet is a rocky type, in the habitable zone, and finally if this planet was 'contaminated' by the life seeds from Earth, then we have what one could dream – an Earth 2.0, orbiting a Sun 2.0," said lead researcher Vardan Adibekyan. By: Amber Jorgenson

Catastrophic floods rapidly carved the surface of Mars 19 November: More than 3.5 billion years ago, water flowed freely across the surface of Mars, forming lakes and seas. New research shows how these lakes may have overflowed and burst at their sides, causing flooding so severe it carved out canyons in the Martian surface over the course of just weeks.


The Jezero crater is a paleolake on Mars. Its outlet canyon, carved by overflow flooding, can be seen in the upper right side of the crater. NASA/Tim Goudge

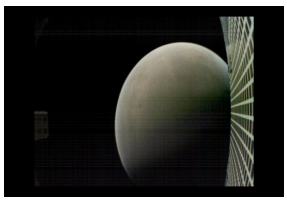
This new research suggests that the flooding could have drastically shaped and altered the Martian landscape and, potentially, other planets that similarly lack plate tectonics, lead author and postdoctoral researcher Tim Goudge. "These breached lakes are fairly common and some of them are quite large, some as large as the Caspian Sea. So we think this style of catastrophic overflow flooding and rapid incision of outlet canyons was probably quite important on early Mars' surface," Goudge said in the statement.

Today, the Martian surface has over 200 paleolakes, or ancient lakes that have either shrunk or disappeared with changing conditions. Flooding from these paleolakes has left behind multiple paths carved by flowing water called outlet canyons. For over 25 years, Goudge said, scientists have known about these paleolakes and outlet canyons. "These paleolakes have long provided some of the strongest evidence that Mars experienced an era when flowing liquid water modified the surface," Goudge added. Only now, with this study, have scientists shown that these canyons were rapidly carved out by single flooding events instead of gradually formed.

The researchers came to this conclusion by studying high-resolution photos of Mars taken by NASA's Mars Reconnaissance Orbiter satellite. "By looking at the topography of the outlet canyons, we were able to show that the outlet size correlates very well with how much water would have drained from the basin during a flood, which is most consistent with their formation rapidly (in the geologic sense) through a single, large flood event," Goudge said. The team is still working to understand just how rapid and severe these flooding events were, Goudge said. But, "some preliminary work suggests [the outlet canyons] may have formed within a matter of weeks to months," he added.

Goudge also had some insight into what these catastrophic floods might have looked like: "The floods would have been very sediment-rich, possibly moving large boulders far downstream, and they may have even initiated as something that looked more like a debris flow than a typical river." Massive flooding events on Earth's have similarly shaped our landscape. When terrestrial lakes have been dammed by glaciers and their water finally broke through, it has created similar outlet canyons on our planet, the statement explained. By: Chelsea Gohd

InSight Mars mission brought a first for NASA: Interplanetary CubeSats 27 November: Yesterday, NASA's InSight lander touched down successfully on the Martian surface in a flawless feat of engineering. Two briefcase-sized satellites known as CubeSats followed the exploratory probe all the way from Earth to the Red Planet. These twin CubeSats are successfully relaying important data to Earth, connecting us to Mars like never before. In fact, these satellites transmitted InSight's descent, landing, and first look at its surroundings almost immediately after the probe safely landed.


MarCO-B took this image of Mars from about 4,700 miles (6,000 kilometers) away during its flyby of the planet on Nov. 26, 2018. NASA/JPL-Caltech

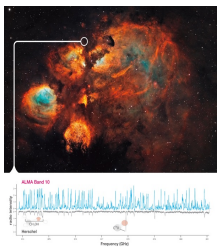
These CubeSats are known as Mars Cube One satellites or MarCO CubeSats (individually called MarCO-A and MarCO-B and nicknamed "EVE" and "WALL-E" from the Pixar film Wall-E). They were developed and built in NASA's Jet Propulsion Laboratory to transmit information from InSight. However, while CubeSats are fairly standardised spacecraft and are often built by students, previously all CubeSats have orbited Earth. The MarCOs are the first to travel to another planet. "MarCO-A and B are our first and second interplanetary CubeSats designed to monitor InSight for a short period around landing, if the MarCO pair makes it to Mars," Jim Green, director of NASA's planetary science division, said. "They are a demonstration of potential future capability. The MarCO pair will carry their own communications and navigation experiments as they fly independently to the Red Planet."

Green's comment suggests that satellites like the MarCO pair could become commonplace in space in the future. Interplanetary missions could carry along their own satellites like InSight did with the MarCOs, increasing communications abilities. Because the satellites are at Mars, they can communicate much faster with vehicles like InSight on the planet's surface. The pair was also uniquely positioned during InSight's landing to catch the entire event and relay it quickly to Earth. The success of the MarCOs could even support future spacecraft landings, as CubeSats allow engineers to record landings in great detail. Before InSight, only about 40 percent of Martian landings were successful, according to NASA. By watching landings with CubeSats like the MarCOs, engineers could improve this statistic.

The MarCOs have also supported scientific exploration at Mars, even though they do not carry any scientific equipment. As MarCO-A flew by Mars, it transmitted signals through the martian atmosphere. By studying how the signals were affected by the atmosphere, scientists could figure out what the atmosphere was made up of and even how much of each component was present. The MarCOs are also able to capture unique images as they pass by the Red Planet and its moons.

The MarCOs - interplanetary devices that connect communications between Earth and Mars - are also extremely cost-efficient, adding to their appeal. "CubeSats have incredible potential to carry cameras and science instruments out to deep space. They'll never replace the more capable spacecraft NASA is best known for developing. But they're low-cost ride-alongs that can allow us to explore in new ways," John Baker, JPL's program manager for small spacecraft, said. By: Chelsea Gohd

ALMA releases first science results with its highest-frequency receivers 29 November: The Atacama Large Millimetre/submillimetre Array in Chile has been up and running since 2011. However, its initial incarnation involved only about one-third of the array's total planned 66 antennas and only a few of its 10 receivers, each capable of observing a different band of radio wavelengths. Over time, the array has taken strides toward full operation; today, all antennas are functional and ALMA has now added its highest-frequency observing band - Band 10 - to the mix.



ALMA's observation of the Cat's Paw Nebula shows more than 10 times the emission lines picked up by the Herschel Space Observatory (grey, inverted to better compare the two). S. Lipinski/NASA & ESA, NAOJ, NRAO/AUI/NSF, B. McGuire et al.

On 22 November, ALMA released its first scientific results with Band 10, collecting 695 emission lines - the fingerprints of vibrating molecules energised by starlight - from molecules in the Cat's Paw Nebula. These molecules include methanol, ethanol, methylamine (a derivative of ammonia), and glycolaldehyde (a simple sugar-related molecule). The Cat's Paw is located about 4,300 light-years away, and is currently forming massive stars. Previous observations at this same radio frequency, made by the European Space Agency's Herschel Space Observatory, detected only 65 emission lines - 10 times fewer than ALMA saw - demonstrating ALMA's immense observing power, especially in a wavelength region not normally observable from the ground. "[These observations] require the extreme precision and sensitivity of ALMA, along with some of the driest and most stable atmospheric conditions that can be found on Earth," said lead author Brett McGuire of the National Radio Astronomy Observatory.

In addition to emission from warm molecules, ALMA also saw jets of heavy water - water composed of oxygen and deuterium (an isotope of hydrogen that contains one proton and one neutron in its nucleus) - shooting from at least one of the massive forming protostars in the region. The team believes these jets are relatively young, just beginning to push outward and into the larger nebula around the forming stars.

Band 10 is ALMA's highest-frequency receiver band, capable of catching signals between 787 and 950 GHz. It was developed by the National Astronomical Observatory of Japan (NAOJ), which also developed ALMA's Band 4 (125–163 GHz) and Band 8 (385–500 GHz). However, unlike ALMA's other bands, these particular receivers were more challenging to construct. Because of the wavelengths they observe, the Band 10 receivers could not utilize superconducting components built with niobium, which is traditionally used in such equipment. Instead, the development team used niobium-titanium nitrides (NbTiN) to create the components in Band 10. The receivers were completed in 2014, and installed in ALMA for use in normal science operations in 2015.

As highlighted by ALMA's recent results, Band 10 is sensitive to complex molecules at warm temperatures, as well as emission from heavy water. These molecules lend insight into star and planet formation, allowing astronomers to glimpse the ingredients that go

into planetary systems based on the molecules present in the nebulae that surround young stars. Band 10 also allows astronomers to peer at objects much closer to home: the upper atmospheres of the giant planets in our own solar system. Getting a better handle on the molecules swirling above the clouds will help us better understand weather patterns at different levels within the planets' atmospheres. By: Alison Klesman

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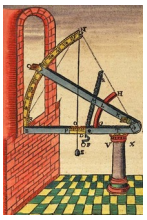
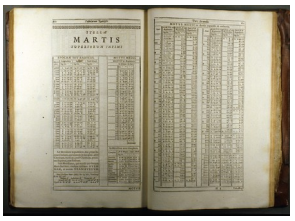
DID YOU KNOW?

Astronomical catalogues Part 2: Tycho Brahe's catalogue: a testament to the importance of accurate observation and measurement


Tycho Brahe


Sextant instrument


Johnannes Kepler



Rudolphine Tables

A 16th century star catalogue was the first major advance on the catalogue included in the Almagest by Ptolemy in the 2nd century CE. As a youngster interested in astronomy, the Danish astronomer Tycho Brahe (1548-1601) realised that rigorous observations and recording accuracy were central to more exact perditions of astronomical events like eclipses. He became the most accomplished observer of pre-telescope era. Aware of the limits of naked-eye observation, he spent much time on optimising the accuracy of his instrumentation which, at that time were sextants and quadrants. He found that larger instruments increased accuracy. He even went to the lengths of mounting instruments on bedrock to avoid the adverse effects of wind and other factors on accuracy.

His detailed work advanced astronomy in several ways, including the understanding of orbital mechanics and increased accuracy in predicted events like the return and orbit of comets. In 1572, he observed a supernova from his own observatory in Denmark. Its occurrence and his measurements showed it to be a very distant event, posing a strong challenge to the existing Aristotilean system of an unchanging universe. Although he published several pieces on his observations and calculations, it was only after he moved to Prague, where he had obtained necessary royal financial support to continue his work, that work on a star catalogue began. The compilation of a catalogue and production of up-to-date and accurate planetary maps was requested by his patron, Emperor Rudolph ll.

In 1598, the completed catalogue with the positions and magnitudes of 1004 fixed stars was circulated in manuscript form. However, he was able to only publish an edited version, listing 777 stars, before his death. Johannes Kepler, who had become his assistant in 1600, then continued to work on the catalogue. The work was completed in 1623, and the full catalogue of 1,004 stars and planetary tables was published in 1627. The 1,004 stars included over 400 from Ptolemy's Almagest. The catalogue had been awaited for several years, with requests on progress from as far afield as India and China as well as Europe. Named the *Rudolphine Tables*, for his sponsoring emperor, it was diplomatically dedicated to the new Emperor Ferdinand ll.

Brahe was the last major astronomer to work without the aid of a telescope. Modern reviews of the *Rudolphine Tables* found positional errors, some due to instrumental

limitations at that time despite Brahe's continuous efforts to improve instrumental accuracy, others probably a result of copying errors. Despite these limitations, information in the *Tables* was precise enough to accurately predict the 1631 transit of Mercury and 1639 transit of Venus. The magnitudes (stellar brightness) given by Brahe also compare well with modern values.

Tycho Brahe's contribution to astronomy was recognised in the 1997 *Tycho Catalogue.* This catalogue also demonstrated how far astronomical observation has advanced since Brahe's time. It contained data obtained by the Hipparcos satellite, which was launched in 1989. Its function was photometry: measuring the position, magnitude, colour, proper motion and parallax of stars. The first edition of the *Tycho Catalogue* included the positions and 2-colour photometry of 1,058,332 stars. A re-analysis of the Hipparcos data resulted, in 2000, in the *Tycho-2 Catalogue,* which contains data on 2,539,913 stars, down to 12.5 magnitude. These catalogues are particularly noted for its parallax measurements as these are much more accurate than those obtained through ground-based instruments.

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

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